INTERNATIONAL

Chemical Engineering

and Process Industries

Vol. 32, No. 2 FEBRUARY 1951

CONTENTS

Price per copy, 1s. 6d. *Subscription rates on application*

England: Leonard Hill Limited, 17 Stratford Place, London, W.1 *U.S.A.: British Publications Inc., 150, East 35th St., New York, 16*

Topics of the Month

Jobs for chemical engineers

AS the recent report on chemical engineering manpower showed, the demand for chemical engineers is considerable and the opportunities limitless. This is all very comforting to young men entering the profession, but also a little bewildering. Which industry should they enter? Which offers scope for particular interests and ambitions? What of salaries?

A creditable attempt to clear up these questions for their 1,000 members is to be made by the graduates' and students' section of the Institution of Chemical Engineers by staging a convention entitled 'Chemical Engineering—Opportunities in Specific Industries.' It is to be held at Nutfield House, Brown Street, London, W.1, from Wednesday to Sunday, April 11-15.

While the theme of the convention is a general one, each lecture will relate to conditions in a specific industry and will be given by a senior chemical engineer or other recognised authority. The series will show graduate members the way in which their work and problems reappear in modified forms and are variously solved in other industries. For student members the convention should afford an invaluable means of assessing where their future interests might lie and the type of work which would be required of them. For all members there will be an opportunity for technical and personal discussions with chemical engineers from other industries and universities. It is hoped that firms will encourage industrial members to attend and that holding the convention in the Easter vacation will be convenient for students.

Seven industries will be considered in the lectures: Gas, iron and steel, edible oils, low temperature, atomic energy, non-ferrous metals, and plastics. Besides this there will be visits to factories as diverse as Fords and Tate & Lyle. The convention deserves the full support of industry and we hope that it will help many young chemical engineers to decide how best they can practise their profession.

Sulphur and acid rationing

THE long-awaited details of the sulphuric acid rationing scheme were released on January 8, from which date the scheme took effect. A basic period, April to September 1950, has been taken as the basis of the scheme.

In general, consumers of crude, recovered or processed sulphur or of acid produced from crude sulphur are restricted to two-thirds of their takings in this basic period. Consumers of acid derived from materials other than sulphur are not so far materially affected.

The Board of Trade announcement giving these details states that the requirements of all consuming industries are being further studied as a matter of urgency, and the Government departments concerned will be considering what adjustments in these rationing arrangements are necessary in the interests of the national economy. It seems,

therefore, that we have entered into a fluid period as regards sulphur and sulphuric acid supplies.

So far as the immediate future is concerned, the situation will obviously depend on deliveries of American sulphur, since it is upon this that about 60% of British acid production is based. During 1951 Britain expected to receive 500,000 tons of U.S. sulphur. In fact, for the first quarter only some 81,000 tons *for all purposes* have been allocated to this country.

The outlook is indeed extremely unsettled. Even if the most optimistic view is taken, it is clear that the British chemical industry's programme of expanding capacity to 2,134,000 tons p.a. within the next four years has received a disheartening setback, for it is certain that this programme relies heavily upon a continuation of ample supplies of imported sulphur.

Apart from the U.S., the only other major source of sulphur is Italy. It is reported that Italy has offered the Organisation for European Economic Co-operation 200,000 tons in 1951-52, rising to 250,000 tons in 1952-53, 350,000 tons in 1953-54 and 450,000 tons in 1954-55.

Large-scale development and re-equipment of the mines will be necessary to win these quantities of sulphur and, no doubt, the costs involved are one reason for Italian supplies being almost twice as dear as American. Efforts are being made to induce the Italians to reduce their prices, but so far there seems to have been little effect. In any case, the Italian chemical industry strongly opposes the export of this vital raw material, basing their antagonism on the familiar theme that it is more profitable to export high-value intermediates and finished products than raw materials.

Bearing in mind the fact that sulphur reserves are dwindling rapidly, it is clear that sooner rather than later the chemical industry all over the world will have to face up to the fact that other sources of sulphuric acid must be developed urgently.

More complicated plant is needed to produce acid from other materials, such as anhydrite and pyrites, and it is the cost thereof which has deterred the large-scale development of these processes. Faced with Hobson's choice, producers will have to make these outlays and, if necessary, Governments will have to help them.

Concurrent with such schemes should be major efforts to conserve acid in those processes where it is consumed in the greatest quantities, superphosphate manufacture, for example. Here again more elaborate and costly plant will be needed.

Whichever way we look at it, the sulphur crisis means more work and more opportunities for chemical engineers.

Research on drying

IN this issue a special emphasis is given to the subject of drying. Besides starting a survey of modern drying plant, we publish abstracts of particularly interesting papers given before the special meetings of the Institute of Fuel devoted to 'A Study of Drying.' That much more attention should be given to the fundamentals of drying is emphasised by the recent decision of the Department of Scientific and Industrial Research to survey the literature of the subject. So far as is known, the only published general bibliography on drying is that consisting of 500 references contributed by E. A. Alliott to the second volume of the *Transactions* of the Institution of Chemical Engineers. The D.S.I.R. aim to produce a new bibliography and to discover what fundamental aspects of drying are particularly in need of investigation.

Germany's booming chemical industry

THE German chemical industry is well on the way to becoming one of the country's chief exporting industries. Trade circles expect the value of exports of chemical products in 1950 to be some $200,000,000, compared with $95,000,000 in 1949. The proportion of chemical products in total West German exports this year is estimated at 12 to 13%, compared with 14.3% in 1938.

Germany's contribution to the world's chemical trade before the war amounted to $299,700,000, or 24.4% of a world total of $1,220,000,000. The value of West German chemical production in 1949 was some $1,000,000,000, and that of the Soviet Zone, $360,000,000, out of a world total production valued at $10,700,000,000. The structure of the German industry has been fundamentally changed by the partition of Germany since the war. On the average, 75% of the products of the German chemical industry—and in some items, such as coal-tar dyes, pharmaceutical products and mineral dyestuffs, as much as 90 and 100%—are produced in Western Germany. Pre-war comparisons are therefore of little value. The West German Federal Republic already accounts for 5.4% of the world's production of chemicals, and is the fourth largest producer in the world. The Soviet Zone supplied about 2% of the world's total production. The target for West German chemical exports in 1952-53 after the end of Marshall Aid is $300,000,000 to $350,000,000 p.a.

According to Herr W. A. Menne, of the Chemical Industry Trade Association, the industry is unlikely to provide much justification for the fears now being voiced abroad about German competition. The German chemical industry was fighting for its existence, he said. At the same time, it was his opinion that chemical exports would have to be greatly expanded in order to pay for Germany's essential imports. Old markets would have to be regained, and for this to be achieved development and research were necessary.

Synthetic rubber intermediate from paper mill waste

THE potentially grave effects upon other user industries of the increased demand for petroleum and its derivatives made by the Americans' decision to expand their synthetic rubber industry are hinted at by the item in our news columns of the prospective decline in synthetic detergent production because of the new rubber programme. Sources of synthetic rubber intermediates other than petroleum are, therefore, being sought. One which shows some promise is the paper mill. According to Prof. K. A. Kobe of Texas University, the sulphite pulping of spruce yields a by-product known as *p*-cymene. This, in turn, is the raw material for a chemical called *p*-α-dimethyl styrene, which may replace or supplement styrene, one of the principal intermediates in the manufacture of GR-S or Buna-S rubber.

Prof. Kobe told a meeting of the American Chemical Society that synthetic rubber made with *p*-α-dimethyl styrene has proved superior in tensile strength and more like natural rubber in processing characteristics than rubbers made from styrene.

If all this is true the North American sulphite pulp industry can make a powerful contribution to the synthetic rubber programme, for it is estimated it could turn out at least 1,300,000 gal. of *p*-cymene p.a. Obviously a firm market will have to be created before the industry will install the equipment needed to recover the by-product in these quantities.

Protection against nuclear radiation by means of drugs

OF all the lethal effects of atomic energy, those resulting from ionising radiations are regarded with the greatest horror, probably because we know so little about combating them and about their ultimate effect upon the human organism. Every balanced person fervently hopes that the world may be spared an atomic war and that it will be unnecessary to discover how to combat radiation. However, the atomic bomb is not the only means of generating radiations. Any use of atomic energy creates a risk of excessive exposure of human beings to radiation. Therefore, if we are to live with atomic energy, means of protection are essential. So far the only certain protection is the lead or concrete shield, which prevents radiations from reaching living tissues.

This means of protection is not always practicable, however, and it is natural that physicians, biochemists and others have turned their energies towards the possibilities of protecting the human organism against radiation by chemical means.

From what is so far known of this work, everything is as yet tentative and exploratory. There are conflicting theories as to the effect of radiation on the tissues. If it is true that it disrupts the chromosome, then the only protection is the lead or concrete shield. However, if we accept another theory, that ionising particles exert their effect by chemical means, it is not fantasy to conceive of a drug which could combat these effects.

Although so far no drug has been found which is of practical value, the trend of thought is shown by the fact that the amino-acid, cysteine, diminished the mortality of mice exposed to lethal doses of x-irradiation when administered just before exposure. Glutathione (a tripeptide of glycine, glutamic acid and cysteine), thiourea and sodium ethane dithiophosphonate have similar positive protective powers.

If we approach the subject from the biological rather than the physical or chemical angle, three major causes of death from radiation can be catalogued: Haemorrhage, infection, and other complications. Against haemorrhage substances having 'vitamin P' activity have been shown to reduce the mortality in dogs. Quercetin and ascorbic acid also gave significant protection.

Death with infection is extremely common following mid-lethal doses of radiation, and here the antibiotics have been found partly effective. The so-called golden antibiotic, aureomycin, seemed most effective in that it prolonged the survival of irradiated dogs and rats by a week.

As for the third group of lethal effects, hormones like oestrogen have opened up new lines of enquiry. Experiments on mice at Chicago have led workers to believe that the spleen secretes a substance like a hormone which, although it does not prevent death of cells in the marrow, permits a very much more rapid regeneration.

Fuller details of all these investigations are given by Dr. J. F. Loutit, director of the Medical Research Council's radiobiological research unit at Harwell, in the current (February) issue of our associate journal, *Manufacturing Chemist*.

Although the results must be considered with extreme caution, they show that scientists are gradually getting a clearer picture of the physiological effects of atomic radiation as a preliminary to devising chemical protective agents.

Fewer contributions to the literature of chemical engineering

IT seems that chemical engineers are becoming progressively disinclined to contribute to the literature of their work. This must be the conclusion from a study of the number of papers contributed to the *Transactions* of the Institution of Chemical Engineers during the past 27 years which appears in the current *Bulletin* of the Institution. From 1923-40 an average of 14 papers p.a. were contributed. Since then, in spite of the increase in the membership of the Institution from about 500 to well over 2,000, the average has been only 13 p.a. The intervention of the war years is probably one reason for the decline. However, the Institution is not happy about the present trend and it publishes the figures in the hope that they will stimulate members to take stock of their personal contributions in this respect.

It is interesting to compare contributions on a subject basis. Up to 1940, materials of construction, including corrosion, drew the greatest number of papers followed by industrial and manufacturing processes and effluents and waste materials. Mixing and agitation drew the least number of papers—one, to be exact. New subjects since 1940 have been automatic control and thermodynamics. Subjects which have not been dealt with since 1940 are electrolysis, high pressures and transmission and measurement of materials. A consistently popular subject since 1923 has been distillation and condensation.

Papermaking history

IN 1951 paper manufacturers may well look back on one or two striking points in the story of their craft. Fifty years ago died Francis Tempest, that Englishman who broke all records for a one-man mill in the United States with his Sunnydale mill in Pennsylvania. For 41 years Tempest worked the old stone mill with a 36-in. cylinder machine and a 125-lb. beater. Then, 100 years back, we find Burgess and Watt making the first useful paper from 'chemical' wood fibre. This invention of 'the soda process,' using caustic soda at a high temperature, was used in a Hertfordshire paper mill in 1851, yet interest over here was so lukewarm that the inventors took their process with them to America.

Further still into the past, and we find that 150 years ago there was a Gamble in paper-making just as striking a character as the Gamble who lost a fortune in our alkali industry. John Gamble took out the earliest English patent for a paper machine: 'a sheet of copper screen . . . passing round two cylinders, forming an endless web to receive the pulp. The paper is afterwards wound from between the cylinders upon a wooden roller, for which, when loaded, another is substituted without stopping the machine.' Through the efforts of Gamble, brother-in-law of the eminent Didot in France, the Fourdriniers became interested, spent £60,000 on the machine, and achieved perpetuation in the 'fourdrinier' so well known throughout the paper industry. Our present paper shortage in Britain seems hard going in view of all our contributions to paper-making in the past.

Electronic bombardment preserves food

ELECTRONIC sterilisation of food has been investigated in the U.S. for some years now, but apart from the initial publicity given to the process, little seems to have been published on the subject. Clearly, time is necessary to

prove the claims for the process, which are essentially that it is an alternative to refrigeration for preserving food over long periods. Sufficient time has now gone by for at least a progress report on electronic sterilisation, and this has now been presented by four chemists of Electronised Chemicals Corporation. They informed the 118th national meeting of the American Chemical Society that electronically-treated foods have been found fresh and appetising after as much as four years' storage without refrigeration. According to them, the electronic bombardment, fired in bursts of one millionth of a second duration, sterilises meat, fish, vegetables, fruits and dairy products without destroying their enzymes, hitherto thought to be the cause of spoilage.

The bombardment is produced by a machine called a capacitron, a self-contained unit with high enough radiation output to make it applicable to large-volume industrial processing. The use of the capacitron for sterilisation has been developed over the last few years as a result of the discovery that insects and micro-organisms which cause spoilage of foods are susceptible to its radiation, whereas tissues, nutrients and enzymes are much more resistant.

It is further claimed that by the electronic radiation a highly potent rabies vaccine which destroys bacteria and viruses without harming the so-called antigens can be produced.

Liaison scientists

THE increasing specialisation necessary in the different branches of science is giving rise to considerable anxiety among those concerned with the future of science as a whole. A hundred years ago men like Faraday were able to make fundamental contributions to several quite different branches of science; today the scope of science is so all-embracing that it is becoming physically impossible for a man to rise to eminence in more than one field. In spite of this, co-ordination of the different branches of science is still an essential without which the promise of scientific progress will remain unfulfilled.

To bridge this gap a plea is put forward by the Sondes Place Research Institute in their latest bulletin for specially trained 'liaison scientists'—men whose function, like that of the director of a research laboratory, would be to act as links between specialists in different fields and co-ordinate the results of their work. These men, not necessarily chosen for academic brilliance, would, like their specialist colleagues, take an honours degree in one subject with one or more subsidiary subjects, followed by a period of post-graduate study and research, but, throughout the course, more attention would be paid to the study of the scientific method *per se*. The scientific approach is the one thing common to all sciences, and a study of it, coupled with post-graduate work, including some research, together with a study of the basic principles of sciences closely related to the principal one taken, should equip a man as a co-ordinator working side by side with the specialists.

Such men would also have their place in technology, where far too little use is at present made of the scientific method, and they would have the additional advantage of acting as 'liaison scientists' not only between specialists, but between scientists and laymen where it is often difficult for the scientist to put over his point of view and the results of experiments to a non-technical management. The report concludes: 'If the policy of turning all promising young students of science into specialists persists, it is difficult to see how we can avoid creating a state of chaos in the scientific world which can only lead to frustration.'

International discussions on welding

AN international welding congress is to meet in London and Oxford from July 14-21 next year. The congress will include the annual meeting of the International Institute of Welding and its various commissions, and is being sponsored in this country by the five British member societies—the Institute of Welding, the British Welding Research Association, the British Acetylene Association, the Welding Sections of the British Electrical and Allied Manufacturers' Association and the Sheet and Strip Metal Users' Technical Association. The president of the reception committee is Sir William Larke, K.B.E.

The congress will open in London on Saturday, July 14, and will be transferred on the following day to Oxford, where three colleges, Christ Church, Oriel and Somerville, will accommodate the 400 to 500 visitors.

Meetings of the 14 technical commissions of the Institute will occupy the first two days, and in the second part of the week there will be three open sessions for the presentation and discussion of papers as follows: 'The Welding of the Wrought Light Alloys,' chairman, Sir Arthur Smout; 'The Welding of Bridges and Allied Structures,' chairman, Prof. J. F. Baker (Cambridge University); and 'Present Trends in British Welding' (chairman not yet appointed).

A full programme of social functions is being arranged, including a concert and a dance in Oxford and a concluding banquet at the Savoy Hotel in London on Saturday, July 21. In the following week, facilities will be provided through the 20 branches of the Institute of Welding for members of the congress to visit works in all parts of the country. The office of the organising committee is at 2 Buckingham Palace Gardens, Buckingham Palace Road, London, S.W.1.

Quaternaries

HOFMANN'S pioneer work in 1851 on the quaternary ammonium compounds brings to mind how comparatively recently have come industrial applications of these derivatives of 4-covalent nitrogen, despite the century they have attained. The student of organic chemistry finds in such compounds absorbing aspects, such as the stereochemistry associated with the quaternary compounds when four different radicles are attached, and also the strong caustic solutions ('strong as KOH') yielded by the quaternary hydroxides. But in sterilising and cleansing technique, low concentrations of such quaternary salts have proved even more interesting since 1935, the year in which Domagk published his studies of the bactericidal properties of cetyl-dimethyl-benzyl ammonium chloride. Surface-active cationic agents come from the ionisation in solution of such quaternary salts in which the positive ion carries a hydrocarbon chain of from 8 to 20 carbon atoms to yield hydrophobic properties.

While in the U.S. and Canada such agents have assumed importance by virtue of their high bactericidal action in small concentrations, combined with absence of odour, taste, and corrosion of metal equipment, comparable applications in Britain are only just developing, under the sponsorship of Resuggan and Davies. These workers favoured a new twin chain quaternary, namely di-octyl dimethyl ammonium bromide, and proceeded to try out others including dihexyl, diheptyl, dinonyl, didecyl and didodecyl as radicles in the 'twin' chains. For sterilising tanks, pipelines, processing and pasteurising plant in food industries and dairy work, there is much promise in these agents once their cost can be brought down to economic figures.

Modern Drying Plant

I. Classification of Driers, Pre-concentration and Mechanical De-watering

By Alan Stubbs, F.C.S., A.M.Inst.B.E., Assoc.Inst.F.

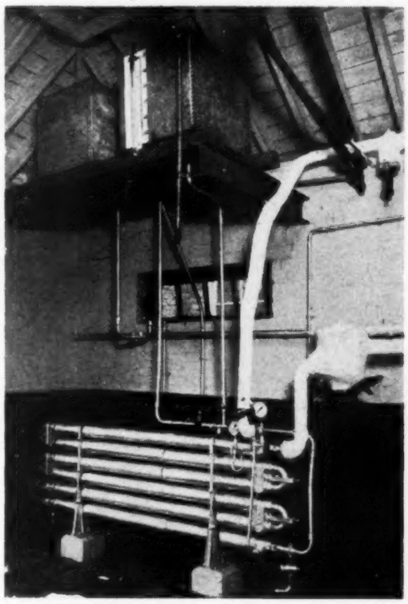
With this article we commence a short series designed to place before chemical manufacturers and others concerned with process drying operations, some of the more recent developments in the field of industrial drying equipment. Such a short series cannot fully detail the vast amount of theoretical, experimental and development work which has been carried out by the leading British chemical plant manufacturers over the past few years. However, results of this work may be seen in the many plants which are now consistently employed in an endless variety of drying operations in a very wide range of industries.

FROM the viewpoint of the user of industrial drying plant a classification primarily based upon the type of material being processed is of far more value than sectionalised lists of available drying units. In considering such a classification, therefore, it is necessary to decide whether or not the material to be dried is (*a*) a solution, suspension, paste, granular solid, sheet or crystal, (*b*) the solid/liquid ratio and (*c*) whether the material is heat-sensitive. To clarify the term 'heat sensitivity' as applied to drying problems it is suggested that this should refer to any material which has a melting or decomposition temperature below 60°C.

From these items and from the types of plant which are constantly in operation a classification based on material can thus be formed. It is given in Table 1.

Definition of drying

Before describing the plants listed in Table 1 it may be as well to consider the implications of the term 'drying' in the light of current practice. While admitting that such processes as centrifuging or filtration go a long way towards producing a dry material, these are, nevertheless, systems of mechanical de-watering rather than drying. No claim is made to remove the entire moisture content of a material.



[*Photo: Kestner Evaporator & Engineering Co. Ltd.*

Fig. 1. Horizontal tube evaporator such as is commonly used today. It consists of a number of superimposed steam-jacketed tubes connected in series by external bends. It is especially suitable for dealing with foaming or scale-forming liquids.

It is difficult to define drying as distinct from evaporation. However, it has been generally stated that evaporation refers to the removal of relatively large amounts of liquid from a material, whereas drying means the removal of relatively small quantities of liquid. In view of the extremely large quantities of liquid which are removed from materials during certain spray-drying processes, however, this definition does not seem quite right. The term evaporation in industry usually refers to the removal of water from a liquid, the resulting product also being in the liquid state. Drying is generally understood as the removal of water from a liquid, semi-solid or solid, the resulting product being in the solid state.

It is, indeed, difficult to obtain a definition which would satisfactorily embrace the immense field covered by the term 'drying.' Probably the most reasonable definition would be: The removal of liquid from a solution, semi-solid or solid material, the finished product being a solid material the moisture content of which is equal to or less than that of its atmospheric equilibrium value.

Treatment of solutions and suspensions prior to drying

It is often economical to remove as much moisture as possible from the

TABLE 1. CLASSIFICATION OF DRYING PLANTS

Materials in solution and suspension		*Semi-solids and pastes*		*Granular solids*		*Materials in sheets*	
Heat-sensitive	*Non-sensitive*	*Heat-sensitive*	*Non-sensitive*	*Heat-sensitive*	*Non-sensitive*	*Heat-sensitive*	*Non-sensitive*
1. Spray driers (continuous)	Spray driers (continuous and batch)	Pneumatic driers	Pneumatic driers	Pneumatic driers	Pneumatic driers	Continuous band driers (vacuum and infra-red)	Tunnel driers and air ovens
2. Film driers (vacuum and infra-red)	Film driers	Continuous band driers (vacuum and infra-red)	Air ovens and tunnels	Continuous band driers (vacuum and infra-red)	Rotary driers	Air ovens and tunnels	Continuous band driers
3. Continuous band driers (vacuum and infra-red)	Continuous band driers	Air ovens (vacuum and hot water circulation)	Continuous band driers	Air ovens (vacuum and hot water circulation)	Continuous band driers	—	Horizontal turbo tray driers
4. Air ovens (vacuum and hot water circulation)	—	—	Turbo tray driers	—	Air ovens and tunnels	—	—
5. —	—	—	—	—	Tray driers	—	—

material by evaporation or mechanical dehydration before proceeding to the actual drying operation, as far less energy is utilised by these processes than by thermal drying operations. The degree to which this is taken will be dependent upon the economics of the process, the limitations of the evaporator or mechanical filter employed and also on the physical nature of the material after processing, bearing in mind the need to convert it into a state in which it can easily be conveyed and handled in the drying unit.

In any drying operation the first requisite is to have the material in such a condition that it can be fed to the plant without difficulty. The required condition of feed for various types of units may be summarised as:

TABLE 2

Drying unit	*Physical characteristics of feed*
1. Film 2. Spray	Pumpable solutions or suspensions
3. Pneumatic	Preferably friable filter cakes, crystals, and granular solids, but pastes can also be handled if pre-mixing is carried out
4. Band	Solutions, pastes or solids
5. Rotary	Granular solids
6. Tray	Granular solids and pastes

With fibrous suspensions which contain large volumes of water it is not unusual that, after removing about 10% of the water mechanically, the resultant residue is in such a physical condition as to be almost impossible to feed to most drying units. The original material, however, could be satisfactorily treated by either a spray or film drier. Thus a balance has to be struck between the advisability of preliminary concentration of the material before drying and dispensing with the pre-treatment and drying the material in the state in which it leaves the manufacturing process. In making the decision the following questions should be answered:

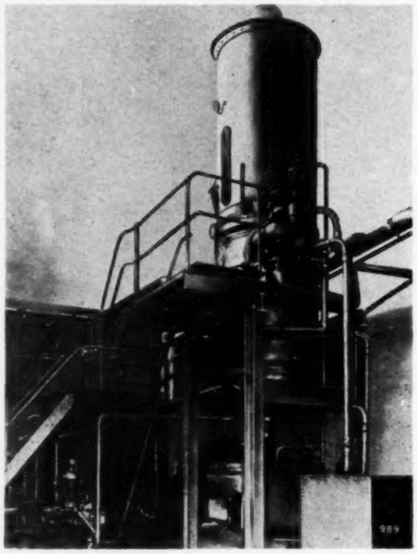
(*a*) What is the maximum quantity of liquid that could be removed prior to the drying operation and what would be the economic advantage in carrying out this pre-treatment as compared with removing the total moisture in one drying process?

(*b*) Would the material produced by pre-treatment be in such a physical state that it could be handled and conveyed without difficulty by any of the standard drying units?

(*c*) Would any pre-treatment affect the physical or chemical condition with which the final product is required to conform?

As stated earlier it is usually more economical to remove as much liquid as possible prior to drying, but this fact does require some consideration and should not be regarded as being applicable on every occasion. Certain materials are ideally suited for such pre-treatment and, as examples among the many, are the concentration of milk extract prior to spray drying and the removal of water from chalk and barytes suspensions by rotary vacuum filtration prior to pneumatic drying.

After the question of pre-treatment has been decided the type of plant in which to carry out this process should be considered. There are many such plants on the market which have through years of operation in the chemical industry proved satisfactory for treating many materials, and much information is available on the type of product obtained from them and its suitability for processing in various drying units.



[*Photo: George Scott & Sons (London) Ltd.*

Fig. 2. Vertical short-tube salting evaporator.

It may be advantageous to review the applications of these plants on a basis of the treatment of true solutions and slurries. The plants suitable for pre-treating the three main groups of material are listed in Table 3:

TABLE 3

Solutions	*Slurries*	*Crystals and Granules*
Horizontal evaporator	Rotary vacuum filter	Centrifuge
Climbing film evaporator (Kestner)	Leaf filter	
Vertical tube forced circulation evaporator (for crystallising solutions)	Filter press	

SOLUTIONS

For the removal of water from solutions there are several types of evaporator, *i.e.*:

Horizontal tube-steam inside tubes. These evaporators were once very popular in the U.S.A. and on the Continent, but are now little used. The liquor circulation was very poor and they were totally unsuited for dealing with scale forming or very viscous liquids.

Horizontal tube - steam outside tubes. Fig. 1 shows a horizontal tube evaporator such as is commonly used today. It is excellent for dealing with foaming or scale-forming liquids.

Vertical short-tube evaporator. This type is also in common use today and is extremely satisfactory for concentrating crystallising and very viscous solutions (see Fig. 2).

'Climbing film' evaporator. This type of evaporator (Fig. 3) is extremely good with foaming or heat-sensitive solutions, but is unsuitable for crystallising solutions.

Inclined tube evaporator-steam outside tubes. This possesses no advantages over either the horizontal or vertical tube types.

From this very brief review it is apparent that the types of plant most suited to the concentration of solutions prior to the actual drying operation are the horizontal evaporator, the vertical short-tube evaporator and the vertical long-tube or 'climbing film' evaporator.

The horizontal tube evaporator

The Kestner horizontal tube evaporator consists of a number of superimposed steam-jacketed tubes connected in series by external bends. If not already approaching its boiling point, the weak liquor being fed to the evaporator passes through a preheater and enters the evaporator through the bottom tubes where it begins to boil and passes upwards through the tubes. During this process the combined volume of vapour and liquor becomes larger, thus increasing the velocity, and the mixture of entrained liquor and vapour is discharged from the top tube into a tangential separator where liquor and vapour separation is effected centrifugally. The vapour leaves from an outlet branch at the top of the separator and the concentrated liquor flows as a continuous stream from the outlet seal pipe.

The heating medium, generally steam, enters the jacket at the top tube and flows downwards counter-current to the liquor flow. The steam condensed in the jacket of each 'element' is separately drained to a pair of condensate header pipes in order that only condensate-free steam is used for heating. The unit may be operated under atmospheric or reduced pressures.

This type of plant is extremely useful for concentrating various salt solutions prior to crystallising and drying. The solution can be satisfactorily concentrated up to its saturation point, when it is discharged into a crystalliser, passed to a centrifuge and finally dried. In such a manner a considerable proportion of water is economically removed prior to the actual drying process. An added advantage with this unit is that the time of contact with the heating medium is so small that fairly heat-sensitive liquors can be concentrated without damage. A comprehensive range of products are concentrated by this form of evaporator.

The vertical short-tube evaporator

This type of evaporator is common in industry and is occasionally called the standard calandria pan evaporator. It consists of a vertical cylindrical shell across the body of which are extended tube plates. The tubes are rolled between the plates and a downtake is provided. The type of downtake varies in different designs of this evaporator, some plants having a large central downtake and others such as the Scott having scattered downtakes. Steam is introduced from a steam chest to the outside of the tubes, thus causing the liquor to boil, spout from the tubes and descend by the downtake. Condensate is removed from near the bottom tube plate and vapour discharges from near the upper tube plate. The concentrated liquor is finally discharged from the base of the shell. These positions vary slightly according to different designs, but in general they approximate those detailed.

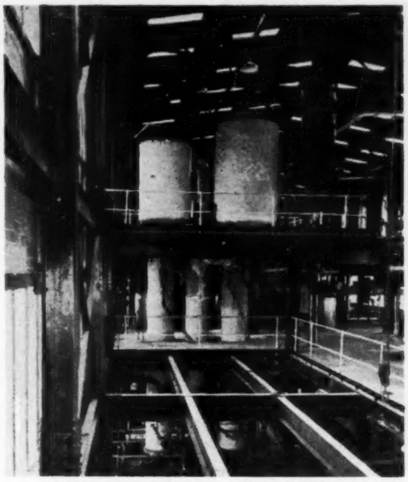
Of these evaporators one of the foremost is the Scott vertical short tube which, as mentioned, employs multiple or scattered downtakes. These have considerable advantages over the older system of a central downtake in that greater use is made of the available heat in the steam by the heating of the liquor in the downtakes as well as the uptakes. The dispersal of downtakes also has the effect of increasing the rapidity of liquor circulation due to the vapour being separated more quickly from the liquor than in the central downtake system.

The vertical short-tube evaporator is successful in dealing with crystallising or viscous liquids but is not suitable for foaming liquors. The cleaning and descaling of tubes in this type of evaporator is a long and cumbersome operation compared with the simplicity of cleaning in long-tube evaporators.

The vertical long-tube 'climbing film' multicirculation evaporator

The Kestner 'climbing film' evaporator possesses obvious advantages in its high heat-transfer rate and capability of dealing with foaming or heat-sensitive liquors. From the viewpoint of heat utilisation it is one of the most efficient evaporators used in industry, and its application is only limited by its inability to handle crystallising solutions. The liquor is only in contact with the heating surface for a very short time and the evaporator is therefore very suitable for dealing with heat-sensitive liquors.

The evaporator which operates on a multiple circulation system consists of two or more steam-heated evaporating stages or calandrias. A single-effect multicirculation evaporator of this type consists of a number of long evaporating tubes contained in steam-heated calandrias, the tubes being expanded into top and bottom tube plates. The weak liquor is fed into the base of one calandria and on entering the tubes begins to boil, thus promoting a column of vapour which rises up the centre of the tubes. This vapour travels at high velocity and in so doing draws up a film of liquor on the inside of the tube walls. The film travels at high velocity up the tube wall and evaporation takes place, the mixture of vapour and partially concentrated liquor discharging directly from the top of the tubes into a separator where liquor and vapour are separated by centrifugal force. The separator consists of a cylindrical vessel containing a baffle. The liquor and vapour discharging from the tops of the tubes is at such a high velocity that, on entering this vessel and striking against the curved vanes of the baffle, complete separation of liquor and vapour occurs, due to the centrifugal motion imparted. The partially concentrated liquor passes from the separator to the bottom of the next calandria in the series and the evaporative process is repeated. The vapour passes from the separator through a common main to the condenser. This type of evaporator may be operated under atmospheric or reduced pressures.



[*Photo: Kestner Evaporator & Engineering Co. Ltd.*

Fig. 3. Double effect 'climbing film' evaporator. Although unsuitable for crystallising solutions, it is very satisfactory with foaming or heat-sensitive solutions.

In relation to drying problems, among the applications of this evaporator is the pre-treatment of solutions such as fruit juices and coffee extracts. A typical example is the concentration of coffee extract prior to the production of soluble coffee powders by subsequent spray drying. The coffee extract containing approximately 5 to 6% solids is passed through the 'climbing film' evaporator operating under reduced pressure. Prior to entering the calandrias the liquor passes through a preheater where the low boiling point volatiles containing the coffee aroma are flashed-off, condensed and collected.

The liquor then passes through the calandrias, evaporation takes place and a concentrated coffee extract containing approximately 35% solids is obtained and collected. The condensate is run to waste, as it is now free from volatile constituents. The concentrate is at a suitable consistency for spray drying and, after this operation has been completed, the low-temperature volatiles previously collected are re-incorporated in the spray-dried powder. Thus a process is provided which is both economical and also retains the desired physical and chemical nature of the material.

SUSPENSIONS AND SLURRIES

Mechanical de-watering is the most obvious method for the removal of liquor from suspensions and slurries prior to drying. The choice of the filtration unit to be used for this purpose depends both upon the economic advantages and also upon the physical characteristics of the residue or cake produced by any particular unit. In general, products from any of these machines which are thixotropic in nature constitute a more complicated conveying and feeding problem than do friable filter cakes or solutions. There are systems in which these thixotropic materials can be processed and satisfactorily handled, but they make necessary a further stage in the process between the filtration unit and the drier. The ideal object of mechanical dehydration of slurries and suspensions is to economically remove as much water as possible from the material and at the same time remove the residue from the machine in the form of a friable cake.

It is appreciated that this cannot be achieved with certain materials, due to their physical nature and, therefore, the problem in these cases should be resolved by considering the relative advantages of (*a*) dispensing entirely with mechanical dehydration and drying the material directly from a low solid concentration in one unit, and (*b*) carrying out some removal of water by mechanical means, followed by further processing of the residue prior to drying, as mentioned earlier.

Under certain circumstances this latter method is better, especially where the material leaves the production process at a reasonably high solid/liquid ratio. For example, clay containing 20 to 25% moisture is quite friable and no difficulty is experienced in handling it in this state in many driers. After processing by a rotary vacuum filter, a clay suspension produces a cake having a moisture content of approximately 30%, and very little further mechanical treatment or pre-mixing is required in order to reduce the moisture content to the stage where the physical characteristics of the clay depart from those of a pasty mass to those of a friable material. On the other hand, due to their colloidal nature, certain protein suspensions do not approach the friable state until the moisture content is reduced to approximately 40%. By mechanical dehydration the moisture content of the suspension may be reduced from 90% to about 80%, at which concentration the product is a pasty mass. In this case it is preferable to dry the material directly

from its liquid state, that is at 10% solid concentration.

In order to produce a satisfactory filter cake for subsequent drying, the best system of mechanical dehydration is undoubtedly the traditional filter press of either the chamber or plate and frame type. It produces a firmer and drier cake than any other filtration method, but unfortunately it has also certain obvious disadvantages which have caused a decline in its popularity. The current trend in industry is towards continuous operation of processes, so that the batch-operated filter press has this initial limitation. Furthermore, it is costly in the replacement of filter cloths, requires considerable attention from operatives and is not suited for dealing with very large volumes of liquor.

One of the more important types of continuous filter for suspensions and slurries is the continuous rotary vacuum filter which, in many cases, is rapidly replacing the older filter press. In between the continuous rotary filter and the filter press is the semi-continuous pressure leaf filter, of which there are several varieties, including the Sweetland, Kelly and Vallez.

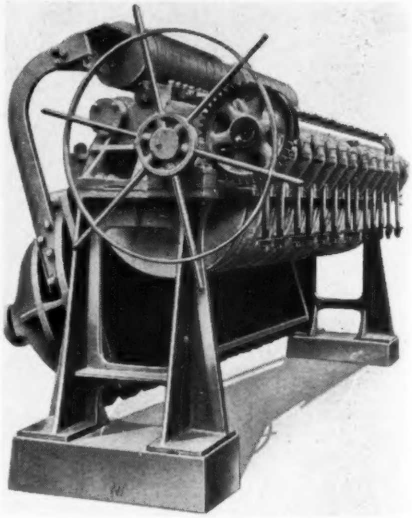
For the mechanical dehydration of crystals or granules, prior to drying, the centrifuge is the obvious choice. However, it should be emphasised that, although the centrifuge is ideal for de-watering crystals and such substances as starch granules, it is not the ideal means of treating extremely fine suspensions. The residue obtained by centrifuging suspensions of fine particles is not in such a good physical state as that obtained by the other methods of filtration mentioned.

The continuous rotary vacuum filter

This form of filtration depends on the application of vacuum to one side of a filter cloth, the suspension to be filtered being continuously applied to the other side. The Oliver continuous rotary vacuum filter (Fig. 4) consists of a drum, the shell of which is impervious and built up of wooden staves, sheet metal or cast iron, depending upon the nature of the material to be treated. The outer surface of the drum is divided into shallow independent sections running the full length of the drum and fitted with drainage grids to support the filter fabric which is secured by wire encircling the drum outside the fabric. The sections are connected to an automatic valve by a pipe and the drum itself is supported at each end on trunnion bearings. While rotating, the drum is partially submerged in a tank, fitted at the bottom with a mechanical agitator promoting agitation to the feed slurry contained in the tank. As the drum rotates, vacuum is applied to the given section by the automatic valve, which draws the liquor through the fabric and out through the valve head into the main filtrate receiver, the solids being deposited as a cake approximately $\frac{1}{2}$ to $\frac{3}{4}$ in. thick on the outer surface of the drum. The vacuum is maintained on the particular section until the cake is almost at the point of cracking, when wash water is sprayed on. Final de-watering of the cake is then carried out and an additional removal of moisture is sometimes obtained by employing a mechanical beater or heavy revolving roll. The cake is loosened from the fabric by the automatic valve shutting off the vacuum, and a back pressure of steam or air finally loosens the cake, which is removed by a scraper or discharge roll.

This sequence of operations is carried out in an unbroken cycle from the feeding of the suspension on to the drum to the removal of the filter cake from it. The rapid formation of a thin cake is in marked contrast to the older method of filtration where thick cakes were built up, and the outstanding efficiency of the rotary filter results from this thin cake formation, due to the fact that generally with most materials the filter rate decreases approximately to the square of the thickness of cake.

There are several filters which operate on the principle described. All are continuous, but differ in design, largely depending upon the nature of the material to be filtered. These include the continuous disc filter, the tube thickener and the Dorrco filter.

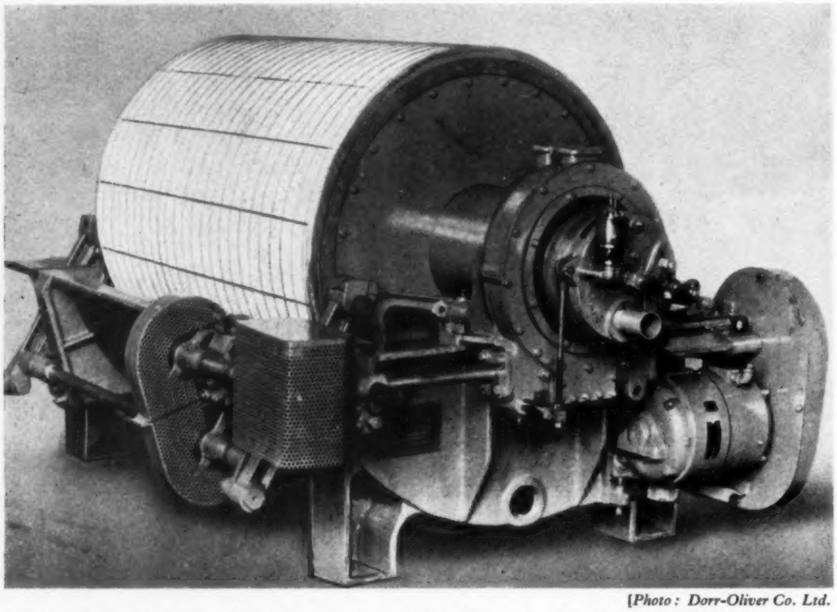


[Photo: Dorr-Oliver Co. Ltd.

Fig. 5. Sweetland leaf filter.

Considerable success has been obtained with the rotary drum vacuum filter in the de-watering of such finely divided suspensions as barytes, magnesium trisilicate, calcium carbonate, whiting and clay. It is unfortunately true that, before proceeding with continuous pneumatic drying of the filtered materials, further pre-mixing and processing of the filter cake has to be carried out. However, this further operation can be done quite satisfactorily and the economics of drying the materials quoted by vacuum filtration, followed by pneumatic drying, are reasonable and the operation is both continuous and efficient.

It should be emphasised that these materials are but a few examples from a large number of products where the detailed sequence of operations is carried out. To attempt the dehydration of the large daily tonnages of these materials by the batch-type filter press would prove impossible and it is for this reason that rotary vacuum filtration leads the field.

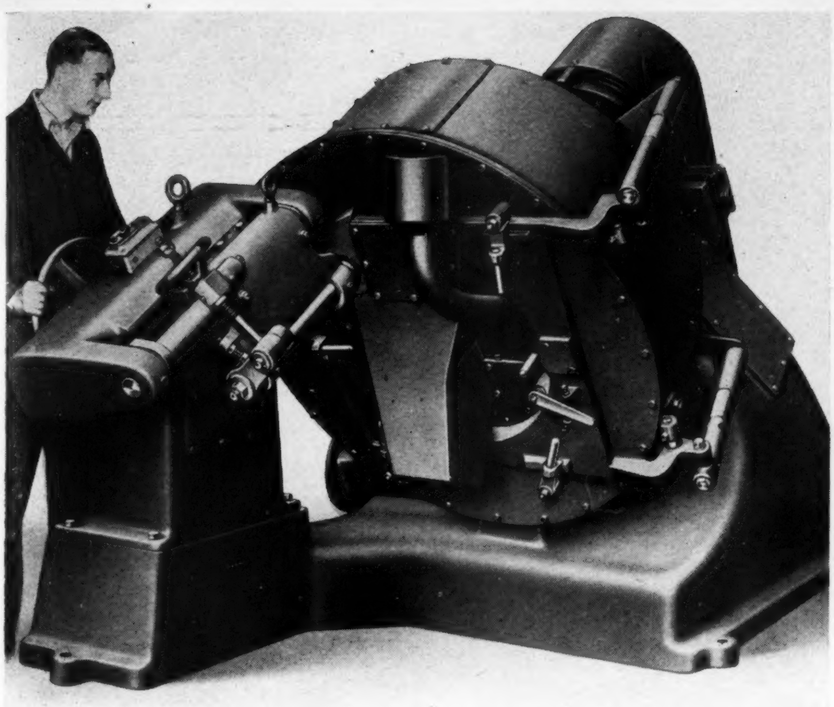


[Photo: Dorr-Oliver Co. Ltd.

Fig. 4. Drum type continuous vacuum rotary filter. As the drum rotates, vacuum is applied which draws the liquor through fabric and then into a filtrate receiver.

Leaf filters

These filters are normally used to handle sludges which are difficult to filter, require



[Photo: Thomas Broadbent & Sons Ltd.

Fig. 6. 36-in. inclined ploughing centrifugal with hand-traversing plough. Material to be filtered is fed through the feed pipe in the front of the machine into the basket which revolves at 500 to 1,000 r.p.m.

pressure, and where considerable washing of the cake is required. It has the advantage that it is more amenable to handling gummy or colloidal solutions than the rotary vacuum filter. Also it does not require the manpower needed for working filter presses.

The Sweetland is probably the leading filter working on this principle. It consists of a number of filter elements or 'leaves' suspended within a pressure-tight shell. The leaves are covered with the filter fabric, on the outer surface of which the deposited solids are built up into a cake which may vary in thickness from $\frac{1}{4}$ to $1\frac{1}{2}$ in. The actual filter body is cylindrical in section, the upper half carrying the leaves being rigidly supported and the lower half hinged in order to allow easy cleaning of the interior of the filter (see Fig. 5). The material to be filtered is pumped through a channel in the shell just above the leaves, passing through the sides of the leaves to the interior. The cake is thus built up on the outer surface of the filter fabric and, when a sufficient thickness of cake has been obtained, wash water is sent through in exactly the same way as the filtrate. The cake is finally removed from the leaves by swinging open the lower body and blowing low-pressure air through the discharge pipe to inflate the filter bags and dislodge the cakes which have formed. The solids slide off the leaves into a hopper placed beneath the filter.

It will be appreciated that this is in effect a batch-operated unit, but the filtration is sufficiently rapid for a series of these machines to be operated semi-continuously. No additional labour is required to do this. However, they are not so well suited for continuous operation as the rotary vacuum filter and their use should be confined to those tasks which cannot be done by the former method. Apart from these cases the solid cake discharged from the leaf filter has no added advantage in its physical consistency or moisture content over that removed from the continuous rotary vacuum filter and the choice of filters is a question of filtration efficiency and cost estimates.

CRYSTALS AND GRANULES

The centrifuge

At some stage in the dehydration of crystalline or granular materials the material becomes extremely coarse or the ratio of solid to liquid is so high that it cannot be pumped as a suspension. It is at this stage that the centrifuge is most suited for mechanical de-watering. It is not usually suitable for the removal of moisture from finely divided or easily caking products, due to the high centrifugal force encountered, leading to packing of the residue on the filter base and rendering the mass impervious. This can only be prevented by decreasing the force, which in turn results in a very wet residue. For the filtration of crystals and granules, however, very satisfactory results are obtained with these units.

One of the most common centrifuges to be encountered in industry is the semi-continuous ploughing centrifuge and Fig. 6 shows a Broadbent unit. The material to be filtered is fed through the feed pipe in the front of the machine into the basket which revolves at speeds ranging from 500 to 1,000 r.p.m., depending upon the nature of the material. Dehydration occurs and the extracted liquor is expelled from the outer casing through a discharge pipe. When filtration is completed the solids are removed from the basket by an electrically-driven plough and discharged from the chute at the base of the machine into a conveyor, by which they are transported to the drier.

Choice of filtering units

The choice of a suitable filter depends mainly upon cost estimates. Briefly, it may be stated that for small sizes the costs of rotary vacuum filters are excessive, but are reasonable for large sizes handling considerable quantities of liquor. The labour charges are less than those for operating leaf filters, while these in turn have considerably less labour charges than the filter press. It will be seen that the leaf filter is an intermediate between the rotary vacuum and filter press and is suitable for handling relatively small quantities of reasonably free-filtering slurries.

The actual drying of solutions, slurries and suspensions will be dealt with in the next article.

Foundry sand drier

After several years of experiment a drier for handling foundry sands which is capable of handling as much as 5 tons/hr. of sand, has been developed by the Lennox Foundry Co. Ltd. The method of operation is simple. Air enters the system through an air inlet fan and is blown through a heater and into a vertical drying column. The wet sand on leaving the storage hopper is fed continuously into the hot air stream at the throat of the column where the air is at its highest velocity. Here the wet sand meets the hottest air and evaporation commences immediately. The section of the column increases progressively and the air velocity is consequently reduced. A point must be reached, therefore, when each particle of sand is suspended in the air stream, this point being dependent on the weight of the particle under consideration. As drying proceeds, individual particles become lighter and are consequently carried further up the column until finally being borne away in the air stream to the cyclone separator. The dried sand is discharged continuously from the separator on to a conveyor where it is finally air-cooled and taken to the dry-sand storage hopper. The spent air, which contains only a very small percentage of fine sand particles, can be discharged to atmosphere, or where scrupulous cleanliness is desired, into a textile bag filter. The air heater can be fired by steam, coal, coke, oil, gas or electricity.

A STUDY OF DRYING is the title of a symposium arranged by the Institute of Fuel. It has three main aims: To present fundamental principles involved in the drying of materials and to indicate the main features of drying practice with particular emphasis on the overall thermal efficiency of the process; to focus attention on new methods and techniques of drying; and to draw attention to the need for work on the outstanding fundamental and practical problems. The meetings at which the papers of the symposium are being read will continue until the end of April.

Below we give summaries of three of the papers presented at the first two meetings.

Methods of Estimating Moisture

THE deceptively simple expression 'moisture content' would appear to imply a most elementary analytical determination, although in practice it may well be one of the biggest sources of disagreement between different laboratories. This arises from the complex relation between water and the substance with which it is associated. Moisture is normally present in all materials in the free state, but in addition is adsorbed or otherwise physically bound to organic substances, particularly colloids, to a greater or lesser degree. Thus, when assessing moisture content, one has to take into consideration water in three separate states, free or surplus moisture, physically bound moisture and the chemically combined elements of water.

The main purposes of the moisture test are: To obtain 'real value,' to ascertain keeping quality, to control processes, to decide the nature and degree of processing a material, to decide whether a material is worth processing at all, and to meet the requirements of legal statute or recognised trade practice. In all these cases the true moisture point is not of any real significance. An arbitrary but established and reproducible method is satisfactory if it is recognised as applying to the material in question, thereby making all such tests thoroughly comparative.

Methods of estimating moisture vary over a wider field than any other chemical determination, and Alan H. Ward, Aynsome Laboratories, Grange-over-Sands, Lancashire, gave details of the various oven, vacuum, distillation, chemical and electrical methods.

Drying ovens

There are a great many types of drying ovens and also a wide variety of techniques for their use. The general principle remains much the same in the sense that the test material is weighed into a suitable container and heated for a given time at a given temperature. The principal refinements of the methods lie in the use of vacuum apparatus or incorporating an atmosphere of an inert gas.

Vacuum methods

Vacuum methods of drying normally consist of an adaptation of the ordinary air oven, and they work at approximately 212°F. Under these conditions there is initially fast loss of moisture, but vacuum treatment does not give the extremely rapid drying that might be expected. As already mentioned, exclusion of air interferes with heat transfer, because convection currents are absent and, on the other hand, so many organic materials are of low conductivity. In theory, the right principle would seem to be alternate evacuation and release of dry air into the apparatus, so that any remaining moisture vapour would be rapidly swept out with each successive charge of air.

Distillation

There are a number of modifications of the method for the direct distillation of water, particularly from materials having a high moisture content. In principle they are all much the same, in that the sample is treated with an immiscible liquid such as oil or hydrocarbons. In some methods the liquid is volatile, in others not. The principle is that with increasing temperature the water is distilled from the test sample, is condensed and collects into a graduated side tube where its volume is measured.

Chemical means

Theoretically a very large number of methods of estimating moisture by chemical means would appear to be possible, in view of the many reactions in which water plays a specific part. In practice, however, few of these have been proposed and only one or two (*e.g.* the direct titration technique using the Karl Fischer reagent) have achieved prominence, mainly owing to the difficulty of ensuring (*a*) that complete reaction takes place, and (*b*) that it includes the physically combined moisture present in test materials.

Electrical methods

These methods are essentially suitable for the factory laboratory and hardly adaptable for use in the factory itself. In many modern processes there is a definite need for a rapid means of assessing moisture, even if accuracy is to some extent sacrificed to speed. Recently, rapid electrical methods have come to the fore taking advantage of the fact that the test material by itself is a relatively poor conductor of electricity and that increasing the moisture content raises the conductivity or, alternatively, the electrical permittivity of the material.

Future developments

In addition to these general methods there are many others of limited application. Among future developments there will probably be further refinements of electrical methods of moisture measurement, and it would not be over-optimistic to forecast that within the next 10 or 20 years there should be accurate and instantaneous methods available for the determination of moisture in every kind of material, irrespective of its physical nature.

Air-drying of Solids

SOME of the problems involved in the air-drying of solids and the methods available for the solution of these problems were reviewed by R. Hendry and A. W. Scott, Royal Technical College, Glasgow, who limited their discussion to a summary of general drying theory and an examination of some of the experimental data. Attention was focused on hot-air drying, which is the most representative and most commonly used method. There is in fact very little basic difference between the various methods of drying a given material. The arrangements for supplying heat to the material and removing the evolved vapour may vary, but the rate at which the material surrenders its moisture still remains a common controlling factor.

In drying, the air-stream serves the double purpose of providing the heat necessary for evaporation and of carrying off the evolved vapour. The properties of the air stream are therefore of prime importance to the drying engineer, and the various terms and quantities used in drying calculations were reviewed.

The psychrometric chart

It is possible to construct what is termed a psychrometric chart, which gives the water-vapour content and dew point of air at varying temperatures and relative humidities. This chart is extremely useful in the design stage in the comparison and analysis of possible alternative arrangements of air circuits in driers.

The chart is particularly useful in studying the effects of varying recirculation in a drier. By increasing the amount of air recirculated—with constant inlet and exhaust dry-bulb temperatures—the drier efficiency can be markedly increased. As a result of increased recirculation, however, the wet-bulb temperature in the drier is

raised. The rate of drying is approximately proportional to wet-bulb depression ($t-tw$). In an actual drier the mean wet-bulb depression may be taken as the mean dry-bulb temperature minus the constant wet-bulb temperature. Hence increased recirculation produces a smaller mean wet-bulb depression and consequently a lower rate of drying. These effects can be examined qualitatively.

Apart from its use in design problems the psychrometric chart is invaluable in the analysis of drier test-results. It is not always possible to obtain representative samples of material for moisture determinations during the course of drying, but the progress of drying can be readily followed from dry- and wet-bulb readings at points in the air-flow path. Heat losses due to radiation, cold-air leakage and similar causes will be denoted by a fall in wet-bulb temperature, similar to that which results from the cooling of air at constant moisture content. Also, a complete thermal and moisture balance can be drawn up by means of the chart for a drier test in which air-flows and inlet and exhaust dry- and wet-bulb readings are all measured.

Design of driers

When the design of a commercial hot-air drier for a new material is required, a variety of factors has to be considered. The type of drier is usually fixed by the physical nature of the material. If this is in the form of slabs or sheets, over-draught drying on trays or conveyors is appropriate. This also applies where the material is in smaller particles suitable for drying in layers, but in addition it may be possible to pass the air through the layer of material instead of over it. If the particles are light enough to be airborne, pneumatic drying may be feasible. Rotary driers can be employed for robust free-flowing particles and spray driers for liquids.

The mode of drying having been decided, the next important factors are the temperature conditions to be used and the estimation of the probable drying time. The most satisfactory method of arriving at these quantities is by a series of *ad hoc* experiments on a convenient laboratory scale. The definition of a suitable size of experimental plant is difficult in the case of pneumatic, spray and rotary drying. There is not much published information on correlation of performance with size of plant, but it is obvious, particularly for pneumatic and spray driers, that quite complex scale factors must be considered. There is a wide field for research here, but the experimental techniques involved will not be simple.

Drying in the form of sheets, slabs or layers, however, can be exhaustively investigated on quite small laboratory plants. The rate of drying at different material moisture contents can be found for varying air speed, temperature and humidity and, in addition, the effects of such factors as slab thickness or layer thickness and degree of subdivision of the material can be examined. If the material is heat-sensitive, limiting temperature conditions also will have to be investigated.

In any experimental work of this nature, where so many variables are involved, the number of tests required for a complete investigation can be greatly reduced if the results can be expressed in terms of convenient dimensionless groups of variables. The correlation and application of experimental data on heat transfer, for example, are greatly facilitated by the use of such groups of parameters. Depending on the mode of heat transfer being considered, results can be expressed in terms of Nusselt, Prandtl, Peclet, Reynolds or other suitable numbers. By this means heat-transfer coefficients for a new fluid can now be estimated and heat exchangers designed without the need for further experimental work.

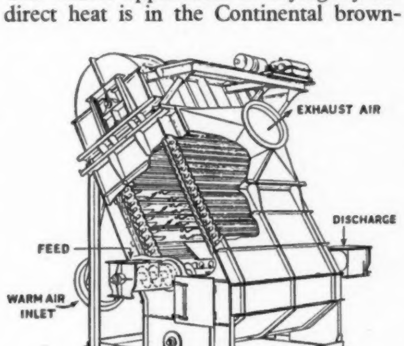
Although the basic mechanisms involved in drying are akin to those in heat transmission, there are obvious difficulties in applying similar methods to the analysis of drying data. These difficulties, however, are not insuperable and it is possible that with a more intensive application of scientific method to the analysis of drying problems, rational bases for correlation will be established. The more complex problem of the mechanism of water movement within solids during drying has received considerable attention in the U.S.A., but this work is still largely at the speculative stage.

Plant for Drying Coal and other Granular Materials

ANY coal-drying problem involves considerations of the physical condition and nature of the coal, and the influence of these factors on the choice of drier was discussed by W. R. Chapman and W. L. Needham (National Coal Board) in their paper, 'The Thermal Drying of Coal,' read at the January 3 meeting held in Birmingham. The description covered the equipment used in the latest American and Continental practice, including rotary drum driers, vertical driers with revolving and stationary trays, cascade driers, screen-type driers and flash driers, as well as driers still under experimental study. The discussion was necessarily confined to coal drying, although the points raised and the plant itself were applicable to the drying of many granular materials.

Drying by indirect heat

Drying by indirect heat is less efficient thermally than drying by direct heat, and is employed only where there is abundant surplus heat in the form of hot gases or steam or to meet special circumstances. The widest application of drying by indirect heat is in the Continental brown-coal mines, where the moisture content of the raw material (50 to 60% inherent moisture) must be reduced to increase the calorific value. For such material, drying by indirect heat has the advantage of avoiding the risks of overheating, and the absence of contact with hot oxygen-containing gases prevents firing inside the drier.



Link-belt, multi-louvre drier (see p. 70) consisting of a chamber inclined at about 30° in which is housed a continuous flight conveyor driven by roller chains.

The Fleissner drying process, first developed for drying Austrian *Glanzkohle* (a form of brown coal), consists in treating the brown coal with saturated steam at 16 to 24 atm. (230 to 350 lb./sq.in.) pressure in a closed vessel for 90 to 120 min. Because the coal is in a saturated atmosphere, evaporation is prevented. The process is intermittent, requiring about 3 hr. for a cycle, and the autoclaves are built-in batteries, each vessel containing 5 to 12 tons. By using batteries, steam from one vessel can be passed to a second by equalisation of pressure to save steam and to promote gradual heating. The product retains the original lumpy structure and is said to withstand weathering about as well as a briquette.

Indirect-heat tubular driers are used for brown coal as a preliminary to briquetting. They are designed to promote rapid heating, since size degradation is advantageous. At some mines the tubular drier consists of a drum, 9 ft. diam. and 21 ft. long and inclined at 5° to the horizontal, with a series of tubes, 4 in. diam., running through the drum and mounted so that the tube structure can rotate. Steam at 40 lb./sq.in. pressure is admitted to the body of the drum. The heating of the brown coal and the agitation in the tubes have a pulverising effect, partly by breakage and partly by bursting of the coarse particles as steam is driven off.

The Lopulco drier, which has been used for drying bituminous coal, consists of a stationary cylindrical casing with a central rotating framework on which a

series of circular cast-iron tables is mounted. Each table has a set of steam coals cast inside it; steam is admitted to the coals from the hollow central driving shaft and the condensed steam is removed through a common drainage pipe. The coal is fed to the uppermost table and is uniformly distributed by a spreader arm; after one revolution it is scraped off into a chute and falls to the next lower table, where it is again spread uniformly and scraped, after one revolution, to the table below. Air is admitted through the casing into each table compartment for the removal of the water vapour. Dust carried forward is recovered by cyclones. The steam requirements are of the order of 2 lb. per 1 lb. of water removed.

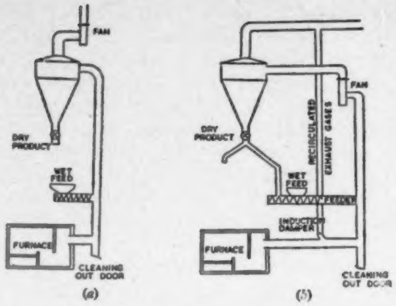
Drying by direct-heat—revolving drum driers

The Ruggles-Coles drier consists of a cylindrical drum with a central cylindrical flue secured to the outer casing. The hot gases pass from the furnace through the central flue and then through the annular space between the two casings back to the inlet end, where they are removed by an exhausting fan. The coal enters through a chute at the furnace end into the space between the two cylinders and travels forward against the returning gases as a result of the downward inclination of the drum. In its travel it is lifted by a series of longitudinal flights secured to the inside of the outer cylinder and dropped repeatedly on to the surface of the heated inner cylinder.

The Büttner drier is a parallel-flow type and operating details are generally similar to those for the Ruggles-Coles drier. In both the Ruggles-Coles and the Büttner driers considerable breakage of the coal is inevitable, and both are bulky.

The Pehrson (or Roto-Louvre) drier is a more compact type of rotary drier. The hot gases are supplied by a fan to a series of tapered longitudinal channels lining the inner surface of the drum, each being covered by a louvre-plate. The hot gases pass through the openings into the bed of coal, which occupies about one-third of the cross-section. The coal travels upward in contact with the louvre-plates in the direction of rotation and tumbles or rolls over itself on reaching the top of the bed whilst the gases are diffused through it. The coal passes quickly through the drier, a length of 15 ft. being sufficient as against 55 ft. for the Ruggles-Coles, and breakage is a minimum. The short drum can be lagged and high thermal efficiencies are obtained. The disadvantage is the need to use two fans, one for the inlet and one for the exhaust gases, but the gases emerge from an extended area of coal surface, with a low velocity, and therefore carry a minimum quantity of dust.

There are other types of rotary drum driers besides those mentioned, but without great differences in design. Rotary drum driers are simple in construction



Simple form of flash drier in which wet coal is fed uniformly into a stream of ascending hot gases.

and operation, but are all more suitable for coarse coals (above $\frac{1}{8}$ in., for example) than for fine coals.

Revolving and stationary tray driers

Driers of this type consist of stationary vertical casings, usually cylindrical, in which the coal falls by gravity from one to another of a series of horizontal trays or tables. The trays may revolve, the coal being scraped from tray to tray by a stationary arm, or may be stationary, passage from one tray to the next lower one being effected by revolving arms which distribute the coal over the tray and discharge it over the outer edge to the tray below. The hot gases usually enter at the lower end and pass upwards through perforations in the trays, thus passing through each layer of coal; or, where the trays are not perforated, they may be deflected from one tray compartment to the next one above it by a series of plates, thus passing over the surface of the coal. In the latter type, the hot gases make direct contact with the coal in its fall from tray to tray, and in this respect they resemble cascade driers.

The Büttner turbo drier has one interesting feature: The trays, which revolve (one in 10 to 15 min.) on a central framework, have radial slots and the coal is scraped through them to pass downwards from tray to tray. A typical turbo drier, 10 m. diam. and 12 m. high, is capable of drying 35 tons/hr. of bituminous slack from 8 to 1% moisture.

The Reol drier comprises a series of circular horizontal shelves made of cast iron, with steel scrapers mounted on a central shaft which revolve at about 5 r.p.m. and scrape the coal from one shelf to the next lower one. In passing through the drier the coal may be subjected to 40 separate drops, during each of which it passes through an ascending current of hot gases. The drier is used in South Wales for a mixture of washed duff and froth-flotation fines before briquetting, and the constant mixing and mild agitation appear to render it suitable for such a coal, though there might be considerable balling if uncleaned fines were treated. A drier about 7 ft. 6 in. diam. with an effective drying height of about 24 ft. can handle about 35 tons/hr. of a washed duff/fines mixture, evaporating about $3\frac{1}{2}$ tons/hr. of water.

Cascade driers

The usual type of cascade drier is rectangular in section and fitted with a series of horizontal star-shaped rollers which revolve, the cup of the star catching the coal as it falls from the roller next above it. Driers of this type are little used, because drying is irregular and very uniform feed conditions are required, but two new designs of cascade drier have recently been introduced in America, and one in Belgium, all of which merit description.

The Baughman Verti-Vane drier. In this drier the coal falls from a feed hopper through a scraping feeder between two sets of vanes inside a stationary vertical chamber, 12 ft. diam. The outer set of vanes is stationary and secured to the casing. The inner set of vanes is mounted on a framework which revolves at about 1 r.p.m. The coal falls under the agitation produced by the revolving inner vanes and the dry coal is collected in the hopper-shaped bottom of the vessel and fed to a worm conveyor for discharge.

The link-belt multi-louvre drier consists of a chamber inclined at about 30° to the vertical in which is housed a continuous flight conveyor driven by roller chains. The coal is fed by a worm conveyor at one side of the drying chamber and near to its lower end, into the lifting flights which carry it upward to the top of their path, the flights thus acting as lifting trays. At the top, as the chains pass over the sprockets, the flights tilt and spill the coal, which cascades downwards and may either be caught by other rising flights or fall to the base of the chamber into a paddle conveyor (continuous with the feed worm), which moves it forward and also throws it back into the lifting flights. As the coal is fed at the side of the drier the flights are first loaded at the end; coal cascading on to a fully loaded flight thus falls laterally away from the feed end. By continuously rising and falling the coal gradually makes its way from the side of the chamber at which it was introduced to the other (or distant) side, where it is collected by the worm conveyor and discharged.

A multi-louvre drier in West Virginia, 9 ft. 9 in. wide, is used to reduce the moisture content of 60 (short) tons/hr. of coal from 7 to 4% as a preliminary to dry cleaning. About 12 installations of multi-louvre driers have been made in America during the last five years.

The Modave drier has been installed for drying clean fine coal from the froth-flotation plant at the Hechteren and Zolder mine, Belgium. The machine consists of a vertical chamber about 40 ft. high, containing a series of horizontal screw conveyors disposed one over the other, each being separately encased inside the main body. The coal enters the upper conveyor, from the end of which it is fed to the next lower one, and it progresses

gradually through each conveyor to be discharged at the bottom.

There are two gas inlets, both at the bottom of the machine. Gases of moderate temperature (300°F.) are admitted at one inlet and pass through channels around and on the outside of each screw conveyor, sweeping each horizontally and then passing by a vertical duct to the conveyor above. They move in counter-flow to the coal, but not in contact with it. At the second gas inlet, high-temperature gases (up to 1,400°F.) are admitted and pass into a vertical flue running to the top of the machine. A portion of these high-temperature gases is added to the 'moderate-temperature' gases at succeeding levels to give a gradually increasing temperature outside the screw-conveyor casings from bottom to top. The exhaust gases are withdrawn at a temperature of 200 to 300°F. and the fine coal, which is dried from 25—30% of moisture to 7—10%, emerges at a temperature of 140°F. The plant at Hechteren and Zolder has a capacity of about 25 tons/hr., involving an evaporation of about 5 tons of water.

Screen driers

Screen driers are not employed in this country, but are in fairly extensive use in America and Canada, where there is a need to remove cheaply sufficient surface moisture to prevent the coal from freezing in winter and, with long hauls, to reduce the cost of transport of inert material.

In driers of this type hot gases are forced downward (occasionally upward) through the coal as it travels forward along a shaking screen. The motion of the screen provides sufficient agitation to give a reasonable uniformity of drying, but only partial drying can be achieved and such driers can clearly be employed only for coarse coal, preferably larger than about $\frac{3}{16}$ in.

On any screen excess water drains naturally from the coal and, as the capillary forces retaining the moisture decrease with an increase of temperature, the gradual heating of the coal results in more effective de-watering by natural drainage, thus reducing the quantity of water to be evaporated.

Flash-, pneumatic- or aspirator-type driers

In flash-type driers the coal is dried whilst suspended in a stream of hot air or gas. Such driers are thus applicable only to quite small particles, and flash-type driers have an application for drying slurry or filter cake prior to pulverisation. They are also used in Germany (Büttner and Rema-Rosin type) for drying crushed lignite before briquetting, for the rapid heat transfer and the rapid evolution of vapour disintegrate the particles and promote uniformity in the product.

The simplest form of flash drier is shown in the accompanying diagram. The wet coal is fed uniformly in the mid-length of a vertical tube into a stream of ascending hot gases generated in a furnace. The velocity of the gases must be sufficient to entrain the largest of the particles, and velocities of 30 ft./sec. are required to ensure the suspension of particles of $\frac{1}{8}$ in. size. The necessary velocity is, of course, greater the higher the temperature. The volume of gases employed is therefore rather high, resulting in the need for large and efficient dust-collecting systems, and it is frequently found necessary to effect a final cleaning of the gases by electrostatic precipitation. High power consumptions are involved, especially for coarse particles; the velocity for a $\frac{1}{2}$-in. particle would be 60 ft./sec. in cold air and about 90 ft./sec. (1 mile/min.) for gases at 1,200°F.

In flash driers more than in coal driers of any other type, the risk of fire is serious, and automatic control must be provided to shut off the feed and/or the hot inlet gases should there be a material rise in the temperature of the exhaust gases. The feed must be at a very uniform rate and be reasonably uniform in moisture content.

At the Braun-Kohlen Bergwerke, Offleben, seven Büttner flash driers are used to dry 125 (long) tons/hr. of lignite from 53 to 15% moisture, giving an evaporation of 18,000 lb./hr. in each drier. The drying tubes are 1 m. diam.; the inlet gases have a temperature of 1,300°F. and one-third of the exhaust gases is recirculated, being taken from a point before the electrostatic precipitator. The volume of gases passing through the precipitator is 40,000 m³.

An interesting application of flash drying is the use of the Lessing de-duster as a drier for raw coal, as a preliminary to dry-cleaning. In the Lessing de-duster the raw coal is fed into a tube through which passes an upward current of air, and the coal is separated into three fractions—fine dust, coarse dust and grains. By substituting hot gases for the air the de-duster has been converted into a drier. Although designed in England the combined hot-air drier-de-duster is not in use in this country. The first installation was made at Beeringen (Belgium), and seven further units have been added to the initial one, bringing the capacity of the plant up to 240 tons/hr. (40 tons per unit, one unit in reserve). The coal is sized 8 mm. ($\frac{3}{8}$ in.)—0 and is dried from 8 to 2.5% moisture, which is 0.5% above the inherent moisture content. The inlet and exhaust gases have temperatures of 1,000 and 160°F. respectively, and the coarse grains of coal leave the driers at about 120°F. The dried coal is dry-cleaned.

Other types of drier

Although there has as yet been no commercial application, considerable preliminary experimental work has been done by the U.S. Bureau of Mines in the development of a drier for fine coal, to overcome the disadvantages of the flash-type drier. The principle employed is to suspend the solid particles in a rising stream of hot gases, the velocity of which is sufficient to keep the mass in a fluid condition but insufficient to cause entrainment of the individual particles. To obtain this fluid condition the velocity of the rising gases must be within well-defined limits, depending upon the size distribution of the coal and the density of its particles and of the gases. Several pilot plants have been erected consisting of vertical chambers 6 to 12 in. diam. and about 6 to 12 diam. high, in which lignites and low-rank coals with 62 to 24% of moisture have been dried to moisture contents usually around 5%. These plants use inlet gas temperatures of over 1,500°F. on entry into the drier column, the temperature falling usually to between 300 and 450°F. where the gases and coal first become mixed; exhaust temperatures (at the top of the column) are between 260 and 300°F. Above the drying column the tube narrows, so that the particles are entrained and carried forward to be collected in cyclones, with a final dust extraction by precipitators or water sprays.

An installation has also been made in America for the drying of washed slack by the use of radiant heat generated electrically. Infra-red radiation only undergoes transformation into heat when absorbed by the particles, and so there are no heat losses to the air. Where electricity is cheap, radiant-heat driers may have interesting possibilities. They might also be practicable if the radiant surface could be obtained from cheap coke-oven gas, the waste gases being also used to supply sensible heat and to sweep away the evaporated moisture. The cost of fuel might be recompensed by the saving in other costs, especially in regard to dust collection, and in added convenience.

A slurry drier is now under experimental trial in France which offers some prospect of success in removing the bulk of the water from sticky materials such as fine unwashed coal. The de-watered slurry is fed by a feeder between two grooved rolls rotating in opposite directions, the pressure bringing the moisture to the surface. The thin band of slurry passes from the rolls to the surface of a larger cylindrical roll where it is again compressed by a number of small rollers in rough contact with the surface. The whole is enclosed in an air-tight brick chamber through which hot gases are made to pass, so that the moisture squeezed to the surface can be evaporated.

Plant for Special Drying Operations

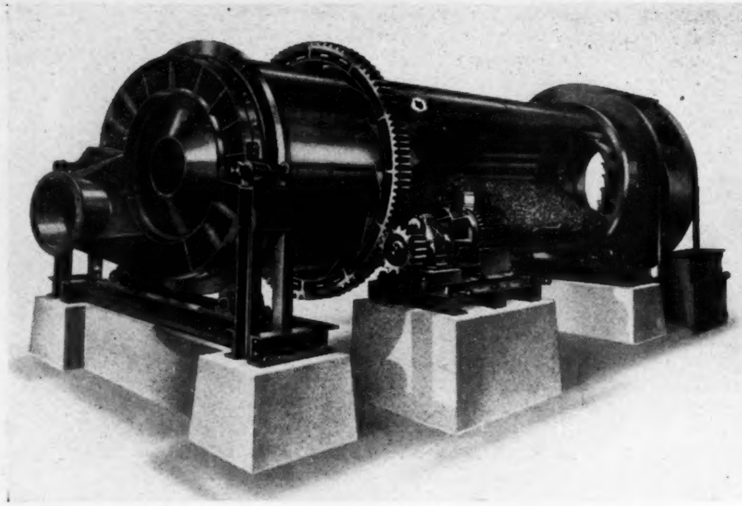
Spray drying. Driers of this type made by Geo. Scott & Sons (London) Ltd., are designed to handle from 4 to 300 gal./hr. of liquid per unit. The plant shown below is for spray drying milk, but many other liquid and pasty materials can be dried satisfactorily by the process.

The liquid to be dried is pumped under pressure to the drying chamber and flows freely into the atomiser, where it is broken into a spray of extremely fine drops. These are then thrown horizontally from the atomiser. Usually the temperature in the drying chamber is between 130 and 175°F. The moisture in the tiny particles is instantly absorbed by the drying air, and the spray is thus transferred into dry powder before coming into contact with the walls of the drying chamber.

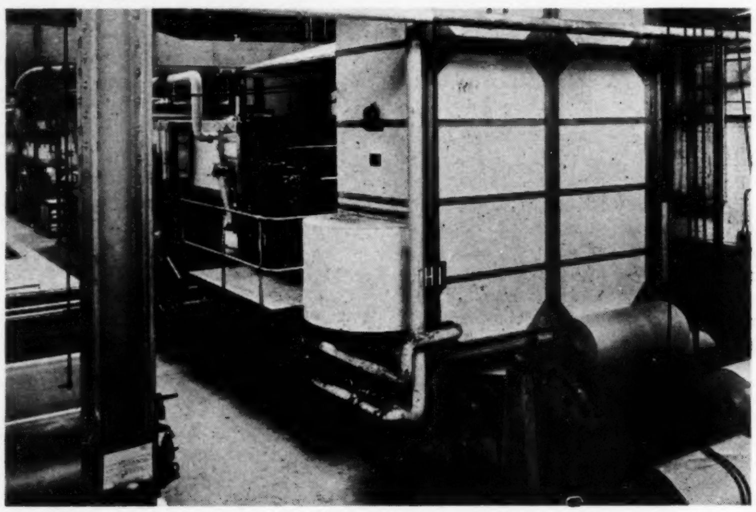
Most of the powder drops to the bottom of the chamber. Part of the material, however, is entrained by the air which is passed through a filter in which all the powder is recovered. The powder recovered from the filter is automatically returned into the main discharge. From the bottom of the drying chamber all powder is continuously collected by rotating scrapers and discharged at one point.

The atomiser in the Scott drier is of the streamlined rotary type, impeller-shaped with wide non-choking passages, rotating at 6,000 to 12,000 r.p.m. with direct electric drive. The whole unit is mounted in a complete motor housing, incorporating special type ball and sleeve bearings. Complete mechanical oil circulation, oil filters, etc., are electrically inter-connected with the atomiser unit. Steam, gas, oil, flue gases or electricity may be employed.

The drying chamber of units for food is almost invariably of stainless steel. Alternative constructions are steel protected by enamel, and brick or concrete with or without enamel linings.



Drying heat-sensitive materials. The rotary louvre plant shown above is especially suitable for this operation. It will treat most solid materials with the exception of those in suspension or solutions in liquid. In a typical installation, as marketed by Dunford & Elliott (Sheffield) Ltd., the material to be processed is fed by means of a vibrating feeder at an even and continuous rate into the rotary louvre drum. The heating and drying medium is provided by means of a combustion chamber which may be fired by oil or creosote pitch, gas, coke or coal.



Drier for paper- or fabric-coating machine. The photograph shows a plant installed by L. A. Mitchell Ltd. for the coating or complete impregnation of papers or fabrics with varnish or synthetic resin. The material produced is used on the decorative side of laminated plastics or high-quality electrical insulation material. The machine is provided with a pre-heating chamber to pre-dry the material to suitable consistency to accurately control the varnish pick-up. A special design of coating head is provided for coating or impregnation as required. After coating, the material is passed through a convection drying tunnel heated by high-pressure hot water for operating temperatures up to 300 to 320°F. The air circulation is designed to ensure uniform treatment of the material and two independent circulating systems are incorporated with a close adjustment on the internal ducting through which the air impinges on the underside of the material through high-velocity adjustable jets. After drying the material is passed over water-cooled rollers and re-wound. The recirculating system employed is designed for high thermal efficiency and provision is made for connections to a solvent recovery plant.

A New Plant for the Solvent Separation of Fatty Acids

The solvent plant which Price's (Bromborough) Ltd. have just put into operation at Bromborough Pool at a capital cost of upwards of £300,000 represents the latest development in the manufacture of fatty acids in Europe. Only three other units of the kind are in existence, all in the U.S.A. The plant is primarily to be used for the production of commercial grades of stearic acid and oleic acid from distilled bonefat fatty acids, but it is adapted also for separation of other fatty materials where differences of solubility exist. Here is a description of the plant.

FATTY acids as obtained from natural fats and oils are mixtures of several fatty acids, some of which are solid, some liquid, at ordinary temperatures; the mixed solid acids from animal fats melt in the region of 125-130°F. Stearine and oleine are finding increasing use in chemical industry, yet, until a few years ago, the means employed for their separation was the same as that used more than 100 years ago, *i.e.* hydraulic pressing. This method effects a relatively poor separation in any one pressing operation, and, in consequence, a great deal of repressing of intermediate products is necessary in the manufacture of commercially acceptable grades of stearine and oleine. Because of the repressing which is necessary, and also because of the extensive use of labour entailed by hydraulic pressing, processing costs are correspondingly high.

The 'Emersol' process

Some ten years ago Emery Industries Inc. of Cincinnati developed a new process (the 'Emersol' process*) for the separation of liquid and solid acids. This process depends on the relative insolubility of solid acids and solubility of liquid acids in methanol at a suitably low temperature.

In essence, the perfected process is very simple, consisting of the following successive steps:—

(a) Solution of the mixed fatty acids in methanol;

(b) Slow chilling of the solution to 10°F. causing the solid acids to crystallise out almost completely, leaving the liquid acids in solution;

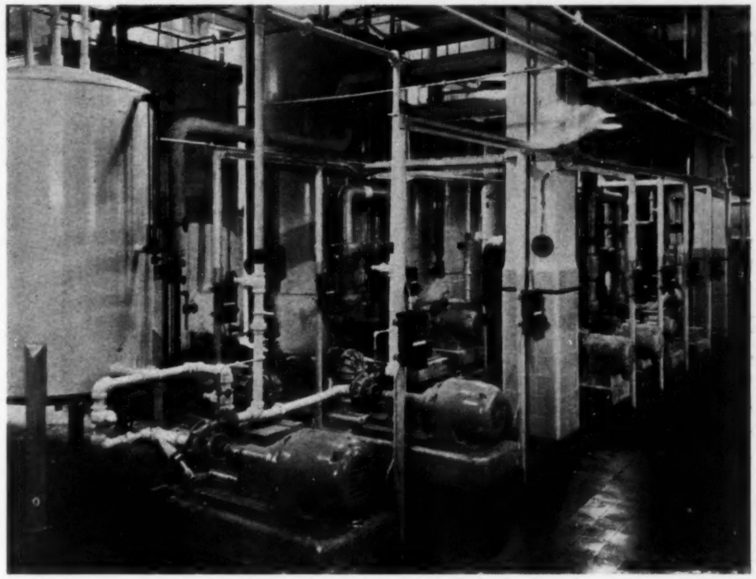
(c) Filtration of the slurry and washing of adhering mother liquor from the cake of solid acids;

(d) Removal of the solvent by distillation and individual recovery of the solid acids (stearine) and liquid acids (oleine).

All these operations have been made continuous and the employment of heat exchangers results in the recovery of up to 75% of the refrigeration provided.

A great deal of development work had to be undertaken before the process was brought to its present state of perfection, in which a sharp separation of the solid and liquid acids is made without the simultaneous production of any intermediate grades requiring reprocessing. It is the avoidance of reprocessing charges and general diminution in labour costs which makes the 'Emersol' process more economical than other processes. Six men can achieve the same output with the solvent process as about 60 by the older method.

*Brit. Pat. Nos. 632,583, 624,415, 643,851 and Brit. Pat. App. No. 35,299 (1946).



Storage tanks and process pumps.

Choice of solvents

Trials with a number of solvents showed that crystallisation of stearine from hydrocarbon and chlorinated hydrocarbon solvents yields plate-like crystals with poor filtering characteristics, but that polar solvents such as acetone, methyl and ethyl alcohols yield needle-like crystals which can be readily filtered.

As refrigeration is one of the major costs of a crystallisation process, it is desirable to choose a solvent which will effect a sufficiently sharp separation at not too low a temperature. It is also necessary to take into consideration the volatility, stability, toxicity, cost and availability of the various solvents which seem to be suitable. After consideration of all these factors, methanol (methyl alcohol) containing 10% water was the final choice. A 25 to 30% solution of fatty acids in this solvent yields satisfactory results on chilling to 10°F.

There is a maximum rate of cooling to which such a solution may be exposed if a filtrable slurry is to be obtained; higher cooling rates give a precipitate which is difficult to filter. This fact, and the desirability of obtaining good heat-transfer (thus minimising the size of the plant and the quantity of solvent in circulation), has led to the adoption of a countercurrent tubular form of crystalliser, with scraping mechanism to provide continuous renewal of the film of solution being chilled. The speed of scraping has an upper limit set by the necessity of obtaining crystals of filtrable size.

For the removal of the solvent from the separated acids, a method is necessary which will do this in the shortest time and at the lowest practicable temperature, so as to avoid esterification of the fatty acids with the methanol. This has been done by flashing off most of the solvent in a calandria and removing the rest of it in a stripping column with the aid of steam.

The Bromborough Pool plant

The plant now operating at Bromborough Pool represents the realisation on

a commercial scale of the process described above, and it embodies all the improvements developed by the inventors in the past eight years. It has been erected in a completely new building, has a throughput of 2,500 lb./hr., and all parts in contact with fatty acids are of stainless steel or aluminium. Mr. Muckerheide, co-inventor of the process, visited Bromborough Pool for the purpose of putting the plant into operation.

The flow of materials through the process is shown in simplified form in the pictorial flow diagram; the actual plant is illustrated by the photographs.

The crystalliser

Distilled fatty acids and 90% methanol are pumped continuously through flowmeters in the control room and blended together before entering the crystalliser. A small proportion of tallow (up to 1%) may be added to the fatty acids before admixture with the solvent for the purpose of improving the filtering and washing characteristics of the crystallised stearine.

The crystalliser consists of a long bank of jacketed tubes covered with thick thermal insulation. The solution passes in series through the inner tubes, finally emerging at about 10°F. and entering the filter.

Cooling is provided by circulation of methanol through a heat exchanger in countercurrent flow to cold filtrate from the filter, then through a standard type of ammonia refrigerator, and finally through the jackets of the crystalliser tubes.

Rotating scrapers, mounted in the tubes on central shafts and driven by external chain gearing, assist in the formation of a crystal of uniform size and promote heat transfer.

The vacuum filter

This is of the rotary drum type with string discharge. The drum is divided into sections, parallel to the axis, which are isolated from one another but with which vacuum is made or broken through the automatic valve at the end of the drum.

After the washes have been drawn through the cake, vacuum is automatically broken and the cake is lifted from the drum by a series of endless strings which pass round the drum and also round a loose roller placed parallel with the drum about 18 in. in front of it. As the strings pass over the roller, the cake falls into a steam-jacketed trough where it is melted before being pumped away to the stearic still.

Pressing on the top of the drum as it revolves, and carried along with it by friction, is the lower portion of an endless blanket which is kept in contact with the drum by compression rolls. The blanket serves to hold the wash liquor until it is sucked into the cake; it also serves to consolidate the cake as liquor is drawn out of it and prevents cracking and loss of vacuum.

After the cake has been lifted clear of the drum, the filter cloth is sprayed with relatively warm methanol to clean the pores before it dips into the liquor in the filter trough again.

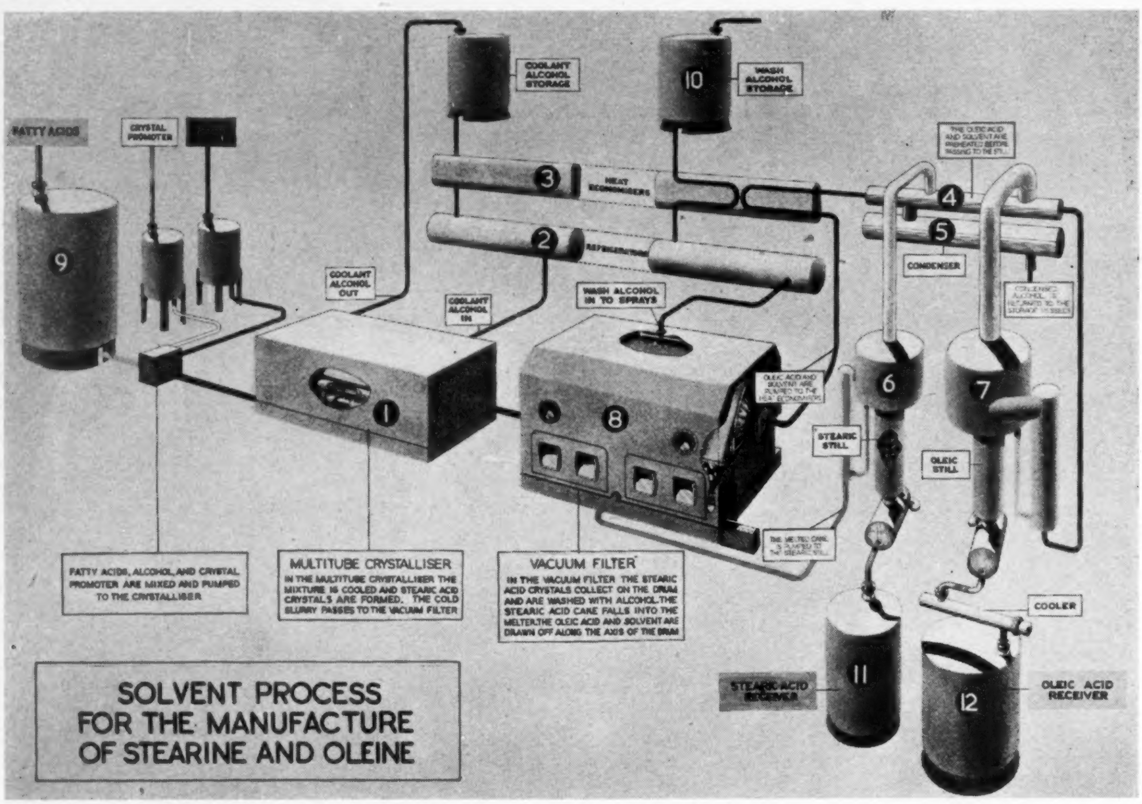
The whole filter is completely enclosed by a hood, and is situated in a cold room maintained at about 20°F. by a 'room-cooler' which is itself cooled by evaporation of ammonia.

The stills

There are two stills of similar design handling the oleine and stearine respectively. The stearine still normally deals with about 3,500 lb./hr. of cake containing about 65% of solvent. The oleine still will take up to about 15,000 lb./hr. of mixed filtrate and wash liquor, and is thus considerably larger than the stearine still.

In each still the feed liquor is fed into the bottom of a steam-heated calandria and partially evaporated to yield a mixture of approximately equal parts of fatty acids and solvent; this is achieved by automatic control of the temperature at the top of the calandria. The liquor then passes down a plate stripping column where the remaining methanol is vaporised by stripping steam rising from the reboiler. A mixture of fatty acids and water (derived from the aqueous solvent) enters the reboiler, which is maintained automatically at 235°F. The fatty acids are separated from the water in a settling zone and are removed continuously by a pump, the discharge rate of which is automatically regulated to maintain a constant level in the settling chamber; the water gravitates back to the reboiler and provides stripping steam.

Methanol vapour from the stills is used to pre-heat the filtrate on its way to the



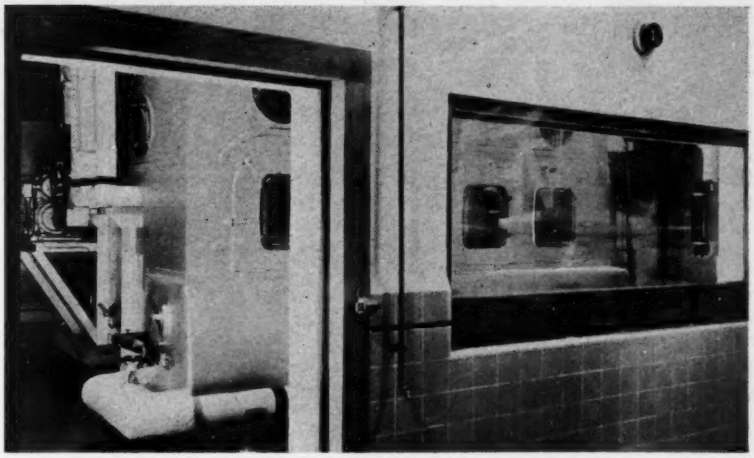
SOLVENT PROCESS FOR THE MANUFACTURE OF STEARINE AND OLEINE

oleic still; it then passes on to a water-cooled condenser.

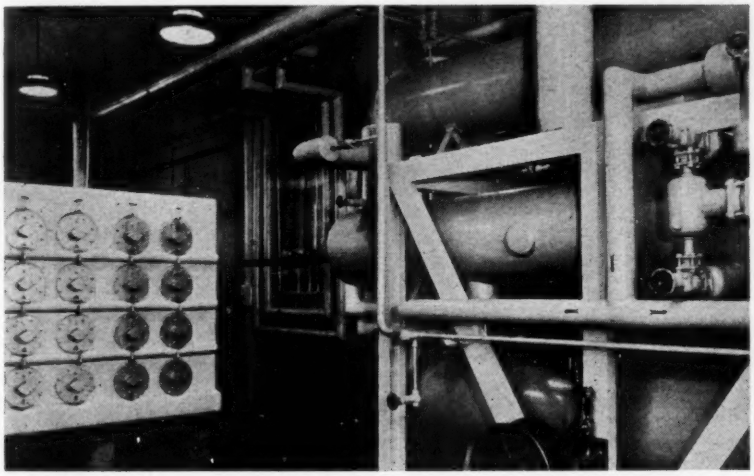
The use of methanol vapour from the stills to preheat the still-feed has just been mentioned. Heat exchangers are also used for the mutual interchange of 'cold' and heat between filtrate and wash-liquor leaving the filter, and methanol on its way to the ammonia evaporators to be cooled. By this means over half of the total refrigeration provided by the ammonia system is recovered.

Refrigeration is provided by a two-stage ammonia compressor driven by a steam turbine, the exhaust from which is used to heat the calandrias of the stills. As already mentioned, the ammonia evaporators are used to cool methanol which is then circulated through the jackets of the crystalliser tubes or used as washes for the filter cake.

A small quantity of liquid ammonia is



Rotary drum vacuum filter with string discharge. It is sited in a cold room maintained at 20°F. by a 'room cooler' which is itself cooled by evaporation of ammonia.



Crystalliser and ammonia vessels, the former consists of a 24-tube heat exchanger.

evaporated in the filter-room cooler, in which air is circulated upwards through a rain of chilled brine.

Control room

Apart from the initial starting of pumps and occasional manual adjustment of the vacuum valves on the filter, practically all the control is exercised by recorder-controllers on the panel in the instrument room. These are powered by dry compressed air at 100 lb./sq. in. pressure, reduced at the instrument to 17 lb./sq. in. According to the position of the recording needle on the chart relative to one which has been preset to the desired value, so a greater or lesser proportion of the 17 lb./sq. in. pressure is passed on to the diaphragm controlling the valve spindle, and the valve is correspondingly opened or shut.

Automatic control is exercised over the amount and temperature of wash methanol provided on the filter, and the temperatures in the still calandrias and reboilers. Manual adjustments can be made on the control panel to the feed rates of fatty acids and solvent passing to the crystalliser, and to the amount of refrigeration provided in the crystalliser. The temperature and specific gravity of the solvent, and thus its water content, can be determined in the control room. The rate of flow of water to the coolers on the roof and also the temperatures entering and leaving them are indicated.

Cooling water is drawn from a pond on the roof at a maximum rate of 800 gal./min., and at a maximum temperature of 78°F., and is returned to the pond, after use, through cooling towers. The water is soft, and make-up is provided by condensate from steam.

Safety precautions

The solvent is both inflammable and toxic, and stringent precautions have been taken to guard against both hazards.

Floors are tiled, and drains have been provided so that any spillage of methanol can be promptly swilled down with hose pipes. Fans have been provided so that the atmosphere can be rapidly changed if undesirable fumes accumulate. Should occasion arise to enter a possibly toxic atmosphere a variety of respirators are available in the building. Process operators are fully aware of the nature of the solvent with which they are working, and the factory medical officer keeps a close watch on operating conditions. An instrument is under construction which will check the atmosphere at various parts of the building and, in the event of the concentration of methanol reaching 200 p.p.m., a warning light and buzzer will draw attention to the fact until the condition is remedied.

In regard to the fire risk, all equipment in process rooms is flameproof. Such items as are not flameproof, *e.g.* starters for the pump motors, are housed in special rooms with pressurising fans drawing air from outside the building.

Other precautions include the wearing of special footwear, the use of non-spark tools, the prohibition of smoking and the carrying of matches or automatic lighters in the building, and limitation of access to persons concerned with operation of the process.

The whole building is divided into three sections which are independent for the purpose of fire-alarm and prevention. If the local temperature in any section reaches 150°F. a warning bell rings, and, 15 sec. later that section is flooded with CO_2 from storage cylinders. If necessary, release can be operated manually from outside the building. Simultaneously with the warning bell, all ventilating and pressurising fans are stopped automatically so that the CO_2 is not extracted.

The solvent plant was designed and erected by the Blaw-Knox Construction Company, U.S.A. Where possible all other equipment was obtained in this country, some of the main items being supplied by the following manufacturers:—

Tanks: London Aluminium Co. Ltd.; Aluminium Engineers Ltd.
Cooling towers: Heenan & Froude Ltd.
Pumps: British LaBour Pump Co. Ltd.
Stainless steel piping: Accles & Pollock Ltd.
Starters: Brookhurst Switchgear Ltd.
Power and lighting conduit: Pyrotenax Ltd.
Thermal insulation: Newalls Insulation Co. Ltd.; Armstrong Cork Co. Ltd.
Fire protection system: Pyrene Co. Ltd.

Chemical and Physical Aids to Iron and Steel Research

Current work at the Physics Laboratories of the British Iron and Steel Research Association is described in the following article.

THE ability of the iron and steel producer to make a precise product with the minimum of raw material wastage is increasingly dependent upon the application of chemical and physical sciences to his manufacturing methods. Some of the current research trends in the industry were demonstrated recently at a series of 'open days' at the Physics Laboratories of the British Iron and Steel Research Association in London.

This Association comprises six divisions, which are all interconnected through three departments, physics, chemistry and operational research, in the sense that these departments carry out fundamental research to assist each of the divisions. Laboratories for these divisions and departments are located in different parts of England, in several universities and in member companies' research laboratories.

The general physics section at Battersea is broadly concerned with the study of the physical properties of steel and the materials used in steel-making, and of the inter-relations between these properties. Two groups of investigations in this wide field have engaged most of the section's efforts during the last three years: those concerned with the possibility of continuously casting steel and those concerned with the behaviour and properties of steel at temperatures right up to the melting point, often higher than those at which it is used, but still of practical importance for its manufacture.

Continuous casting of steel

Work on the problem of continuous casting was begun by B.I.S.R.A. over two years ago, and so far encouraging results are said to have been obtained, but there are at least three major problems to be solved before economic commercial application is feasible. When compared with non-ferrous metals, these problems arise out of the high melting point of steel, its low heat conductivity, and the high throughput of the steel industry. The throughput which has already been achieved in the laboratory is of the order of 1 ton/hr./mould, but there is every reason to believe that this could be increased tenfold.

The experiments have been mainly on casting $2\frac{1}{4}$ in. diameter bars with a mould length of 1 ft. A dummy bar is inserted into the mould for starting the casting operation. In order to avoid splashing of the liquid steel on the mould wall, a hollow steel tube is screwed on to the dummy bar to be a sliding fit inside the mould. The liquid steel first entering the mould freezes and keys on to the bolt attached to the head of the dummy bar. Withdrawal is carried out by means of a set of motor-driven knurled rollers which grip the dummy bar and later the cast ingot as it emerges from the mould.

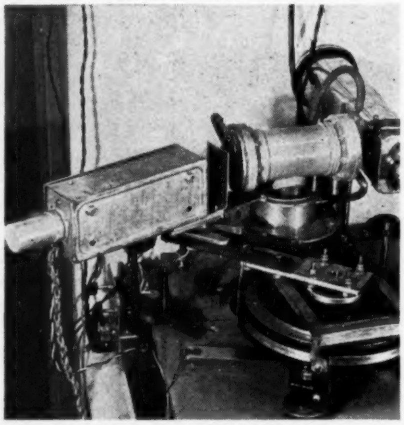
Steel scrap has been melted in crucibles using either a town gas air or oil-fired furnace in quantities up to 50 lb. Many successful casts have been made and the apparatus has now been instrumented in order to measure the following features: (*a*) casting speed; (*b*) temperature of the liquid steel entering the mould; (*c*) temperature of the ingot surface on leaving the mould; (*d*) rate of heat extraction by the mould; (*e*) force exerted on the mould by the moving ingot.

These instruments are now in regular use to provide data on the physical aspects of the process and the manner in which they vary with casting speed, mould length, mould diameter, liquid steel superheat and steel composition.

The problem of pouring liquid steel into the mould at rates which are extremely slow compared with those used in normal steelworks' practice has proved difficult. A reasonably satisfactory method has been found to be the use of a refractory funnel fitted with a small nozzle and heated by a carbon grain furnace to a temperature of about 1,500°C. The nozzle diameter largely governs the speed of casting and is chosen to suit a particular casting speed.

Steel analysis

In another laboratory a new method of analysis of alloy steels is being investigated to see if it is likely to be of practical significance to the steel industry. In this method *x*-rays strike a specimen of the alloy to be analysed, causing it to emit fluorescent radiation. A crystal, a Geiger counter and a recorder enable a reading to be obtained which is a measure of the amount of that element present, which radiates at that wavelength. A new method has been developed for examining phase transformations while they are occurring in steel specimens at high temperatures. After verifying that this gives the same result as existing methods where the latter can be used, it is now being applied to cases which cannot be studied by conventional methods. Parallel to the study of transformation by *x*-ray methods is the development of a microscope of novel design, for the observation of transformations and grain boundary movement of metal specimens while they are being heated in a small furnace.



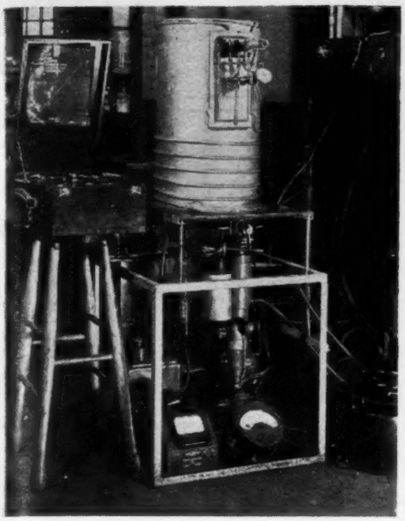
X-ray apparatus for studying phase changes in metals.

Instrumentation

The instruments section is developing industrial measuring instruments and techniques, research instruments and studying industry's general instrument requirements. An electrical meter designed as a remote indicating instrument to measure the furnace differential pressure has been developed and a laboratory prototype instrument has been working successfully on a furnace at Sheffield for two years. The instrument has been further developed for air and gas flow measurement, using normal orifice plate methods. The need arose in the corrosion laboratories for an easily portable instrument to measure residual metal thicknesses of heavily corroded steel plates, of which only one face is accessible. An instrument dependent on the measurement of the magnetic saturation flux density which can be set up through the plate under examination had been developed. Commercial exploitation of this instrument is now being discussed with an instrument maker. In the course of research into the use of different refractories in the open-hearth furnace roof a method was developed for the measurement of the forces between adjacent bricks in a roof arch and for observation of their variation during roof construction, keying, warming up and normal operation.

Thermodynamics

The heat and thermodynamics section has the task of investigating the processes of heat flow and heat liberation. Radiations from solids and flames, calorimetry and temperature measurement are of special importance. Work during the last three



Vacuum chamber housing furnace and constant-stress device used in the investigation of the flow of steel at temperatures ranging from 950°C. to approximately the melting point.

years has centred on two groups of problems. The first is concerned with temperature and radiation measurements of liquid steel, solid surfaces and flames, including the development of apparatus for carrying out sub-standard calibration in steelworks of the temperature and radiation and measuring equipments which are becoming widely used. The second has arisen during the last year and concerns laboratory and large-scale experiments which have been begun with the object of enabling designers to predict the radiation from luminous flames.

Chemistry

The chemistry department and the plant engineering division have space at Battersea. The chemistry department does fundamental research on the physical chemistry of iron- and steel-making processes to support the applied researches of the other divisions. The objects of one investigation are to determine the conditions under which phosphorus exists in liquid iron in contact with an idealised slag, in this case pure lime and tetracalcium phosphate, under various oxidising and reducing conditions. Another research is to determine the sulphur pick-up of simple slags from a gas phase containing known concentrations of sulphur and at known oxygen potentials. Because of the incompleteness of published data, measurements are being made of the heats of formation of inter-oxide and other compounds of interest in iron- and steel-making processes. Such heats are essential for estimating the thermodynamic properties of slags at high temperatures. In another case pure alumina ware is being made for use in the laboratories by slip casting or by moulding. This ware can then be fired to the desired state of hardness.

A New Organic Chemistry Text

PERHAPS the first thing that should be said about this book* is that the formulae are not printed throughout in the Dyson notation. Indeed the author has shown almost too much modesty in this respect and devotes only five pages to this topic out of 40 devoted to the nomenclature of organic chemistry. This particular chapter, on which the author writes with special authority, is especially valuable and is a clear and concise account of a topic which is too often given rather scanty treatment in textbooks. Incidentally in describing the increasing complexity of modern nomenclature it does emphasise that some such system as Dr. Dyson's will have to come eventually, even though many of us will cling rather shamefacedly to the hope that it will not come in our own time.

The book itself is only the first volume of a work which will be completed in three, and is intended as a text book for the final years of graduation and for post-graduate research.

Nominally it is restricted in scope to compounds containing C, H, O and halogens, but in fact it contains a good deal more than these, because many of the appendixes on special topics deal also with heterocyclic and nitrogenous compounds.

The main form of the book follows that normally adopted, with chapters on the hydrocarbons, halogen compounds of hydrocarbons, alcohols, phenols and ethers, aldehydes and ketones, ketenes and polyketides, acids and esters, terpenes, polyalcohols, and sterols, and each of these is given a fairly full and exhaustive treatment, as can be judged from the fact that the hydrocarbon section alone occupies nearly 200 pages. In addition there is an excellent guide to the literature of organic chemistry and the chapter on nomenclature already referred to.

Following each chapter are several appendixes dealing with special aspects of the topic, and these are especially valuable in enabling the author to include accounts of a number of fields of applied organic chemistry such as plastics, perfumery, rubber, petroleum, photography, fermentation, the vitamins and many others. These are useful in providing students with at least an introductory account of topics in organic chemistry which they do not normally encounter until they enter industry, and will also be valuable in giving workers in one field an up-to-date account of what is going on in others. There is also a series of literature references for further reading attached to each chapter, in addition to the normal direct references to original papers which are contained in the text.

The book is pleasantly and lucidly written and is much more readable than most textbooks of comparable size. A very considerable amount of detail has been included which is normally omitted from standard textbooks, and there are many very useful tables of melting-points, boiling-points, etc.

Until all three volumes are available, one cannot judge whether anything of importance is omitted, but this would not appear to be very likely, judging by the scope of this first volume. It is well printed and the proof-reading errors which are almost inevitable in a book of this size appear to be few. On p. 335 the text refers to disodium derivatives where dichloro derivatives is intended, and on p. 901 lanosterol is included in a table of sterols, although its triterpenoid structure has been known for some years. The lists for further reading also contain some surprising omissions—that on the sterols does not mention Fieser's 'Chemistry of Natural Products Related to Phenanthrene' or the very large monograph on this subject in Gilman; but these are minor blemishes in an otherwise very excellent book. If the subsequent volumes maintain the standard set by the first the author will have achieved his purpose of providing an advanced textbook of sufficient scope to fill the gap between the normal textbook and the specialised monographs.

L. J. BELLAMY, B.SC., PH.D.

*_A Manual of Organic Chemistry_. Vol. I: 'The Compounds of Carbon, Hydrogen, Oxygen and the Halogens.' By G. M. Dyson. Longmans Green, London, 1950, pp. 984, 63s.

Abbreviations and symbols

This reference book* has two purposes: (1) To make available in one convenient volume the principal abbreviations, signs and symbols used in a number of scientific and technical fields; (2) To encourage greater uniformity in their use. Both these objects are wholly admirable, and the authors are to be congratulated on undertaking such an exacting task. The material is divided into 17 sections. Those of direct interest to the chemist and chemical engineer are section 3 on chemistry, chemical engineering, physics, heat flow, etc.; section 5 on mechanical drawings, materials of construction, etc.; section 13 on medicine, botany and zoology; and section 17 on technical journals. Since both authors are chemical engineers, section 3 can be regarded as most comprehensive and accurate. The book, of course, is based on American practice, but many British abbreviations, signs and symbols are included. The book is a unique compilation and technical libraries will find it a useful addition to their shelves.

*_Scientific and Technical Abbreviations, Signs and Symbols_ by O. T. Zimmerman and I. Lavine. Second edition. Industrial Research Service, Dover, U.S.A., 1949, pp. 541 including index, $9.

Aluminium Technology

DR. VON ZEERLEDER'S *Technologie des Aluminums und seiner Leichtlegierungen* was first published in October 1933, no revision being considered necessary for the second edition which followed some eighteen months later. This was translated into English by A. J. Field and, although the third German edition was issued as long ago as 1938, it is only now available to English-speaking readers in the excellent translation* by J. Juxon Stevens.

As the author states in his preface, extensive revision and additions were necessary for the third edition, and Mr. Stevens estimates that nearly one-third of the present translation is substantially the same as the Field translation, another third is matter included in the second edition but rewritten by Dr. von Zeerleder in the light of more recent research and development, and the remaining third represents new material. The translator is to be congratulated, however, on achieving a continuity of style throughout which makes for easy reading. This is particularly important, as the book is designed primarily to serve the practical man.

Although the book is based on German practice, procedures and methods, etc., its value to British industry has been greatly increased by the addition, where necessary, of translator's footnotes referring to corresponding or similar British (and in some cases American) practice. Further, in the chapter on properties and methods of testing, the continental standard shapes for test bars have been supplemented by the corresponding British Standard test pieces and complete lists of British and American standards have been added to the list of German standards for aluminium and its alloys as given in the last chapter. Similarly all continental units have been converted into their British equivalents such as B.Th.U., in., ft., lb., tons, etc., and temperatures are given in both °F. and °C. These may seem only small points, but they serve to illustrate the extreme care and thoroughness with which this translation has been prepared.

The scope, as indicated by the title, is extremely wide and, after a short introductory chapter dealing with the history and production of aluminium, there are chapters on the theory of alloys; commercial alloys; properties and methods of testing; furnaces and heat treatment; casting; sheet rolling; extrusion and drawing of bars, tubes and sections; forging, deep-drawing and spinning; wire production; welding and soldering; riveting; machining; aluminium powder manufacture; surface treatment; general considerations in design and construction; fields of application; and standards and commercial forms of the metal. Finally, there is an excellent bibliography of 62 pages in which the titles of the many foreign papers given as references (up to 1937) have been translated into English. In order to cover such a large field, the author has successfully confined himself to essentials, and thus produced an account of aluminium technology which, whilst being scientifically accurate, successfully holds one's interest because it is not overburdened with irrelevant detail.

The book is well produced and excellently illustrated and is a welcome addition to non-ferrous metallurgical literature. It is to be hoped that its reception will justify the obvious care and patience which have been devoted to its preparation.

H. A. HOLDEN, M.SC., A.I.M.

**The Technology of Aluminium and its Light Alloys* by Alfred von Zeerleder. Translated from the third German edition by J. Juxon Stevens. High Duty Alloys Ltd., Slough, 1949, pp. xvi + 451, 311 illustrations. 21s.

Recent publications

Benzene and toluene. Among the petroleum-chemicals products of the *Catarole* process, Petrochemicals Ltd. are now marketing large-scale quantities of benzene and toluene. These reagent grade products are made to a specification which stipulates a very narrow boiling range and a very low acid wash number, and allows only a very small variation in specific gravity.

Detailed specifications for *Catarex* reagent benzene, benzene T.F. and reagent toluene are available on request to Petrochemicals Ltd.

Nimonic alloys. The *Nimonic* alloys were specifically developed to meet the stringent requirements of gas-turbine designers for a blade material which, in addition to withstanding high stresses at very high temperatures, would have good resistance to creep. At the time of their introduction, these nickel-chromium alloys were the only materials which would give the properties required in this type of service. Their first uses were for the moving blades in gas turbines and they soon became standard for every British aircraft gas turbine produced. The development of these uses has resulted in the alloys becoming available in a variety of forms adopted to the specific need of the designer and to assist in the correct choice of the most suitable grade, the alloys have been reclassified. Henry Wiggin & Co., the producers of the *Nimonic* alloys, have recently issued a leaflet which summarises the types available.

Aluminium alloy castings containing nickel. Based on the paper presented by Frank Hudson, F.I.M., to the congress of the American Foundrymen's Society in May of last year, a new publication deals with all aspects of aluminium alloy castings, including early developments, recent metallurgical practice and modern production methods. A tabulated summary of the many alloys available, combined with illustrations showing foundry technique, etc., makes this publication useful to engineers and designers in all industries.

Copies may be obtained free from the Mond Nickel Co. Ltd.

Welding research. The British Welding Research Association's publication, 'Welding Research,' 1950, **4** (4), contains reports on the welding of thick aluminium alloy plates by the argon arc process and on *Hastelloy* fabrication and welding.

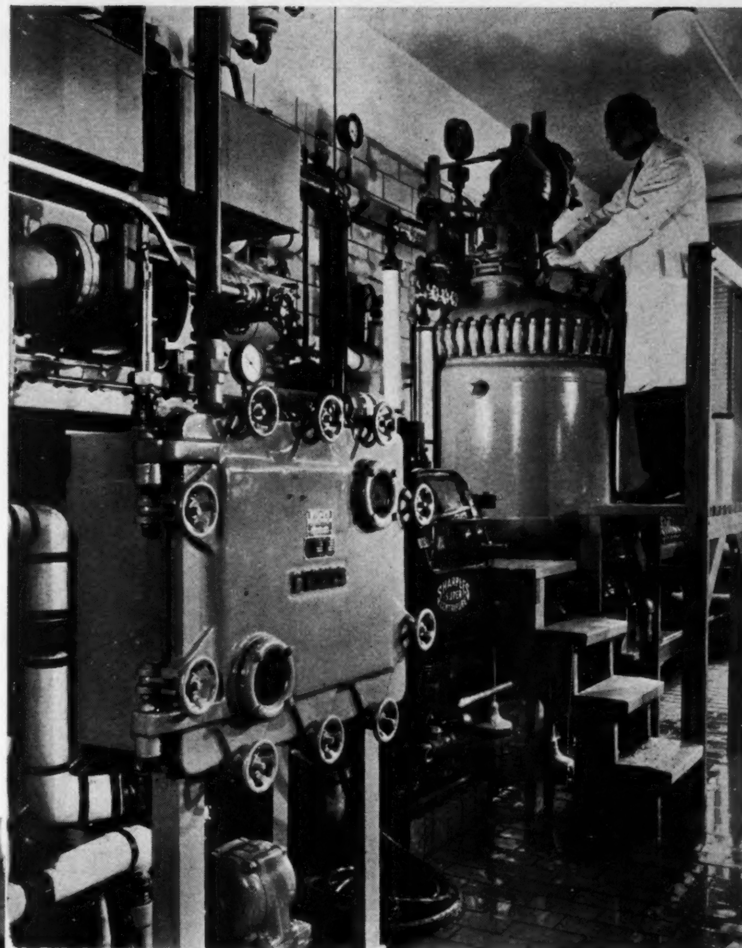
Radiography of welded high-pressure vessels. A statement on photographic aspects of the radiography of welded high-pressure vessels, prepared for the F.E. 6 Committee of the British Welding Research Association on Radiography of Pressure Vessels, reviews the desirable characteristics in the sensitive materials used and sets out recommendations on their handling and processing. It covers choice of photographic materials, handling and processing *x*-ray films, confusing shadows in weld radiographs, formulae of solutions for processing *x*-ray films, etc., and is illustrated by 23 plates and diagrams.

Copies can be obtained from the British Welding Research Association, London, W.1, price 2s.

Pipeline welding. The successful welding of circumferential butt joints in pressure pipelines by the metal-arc process necessitates special techniques, in order to achieve consistent and satisfactory penetration without either the formation of cracks at the base of the welds or the formation of icicles protruding into the bore of the pipe. As a means of giving consistent penetration and root fusion, two main methods are available. The first method involves the use of a backing-ring which may be retained as part of the final joint or may be removable, and the second method involves the use of a base run of weld metal deposited by the oxy-acetylene process. The methods recommended in a memorandum prepared by a panel of the F.E. 10 Committee of the British Welding Research Association on Welded Pressure Pipelines, are the best generally available at the present time, but there are indications that the adoption of special techniques or specially trained workmen may enable backing-rings or oxyacetylene base runs to be dispensed with. Any such proposal should be very carefully investigated to verify that welds made in all positions will pass consistently the test requirements of this memorandum.

The memorandum, entitled 'Recommendations for the Metal-Arc Welding of Butt Welds in Steel Pipelines for Power Plant,' Ref. T.23, covers parent metal, welding methods, reinforcement of welds, supervision of workmanship, heat treatment after welding, tests for quality of butt joints, etc., and includes 28 illustrations. It may be obtained from the British Welding Research Association, London, W.1, price 2s.

Factory-scale Equipment used in Drug Research

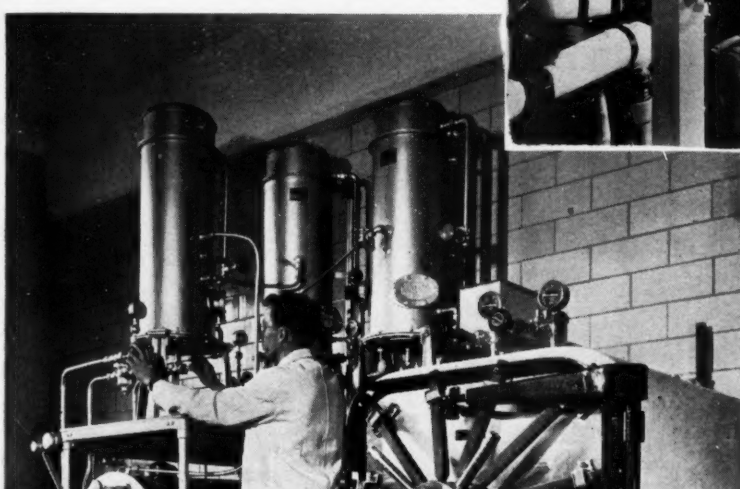


THE scale of operations at the new Sterling-Winthrop Research Institute, Rensselaer, New York, is strikingly illustrated by these photographs which show some of the factory-scale plant used there. They recently appeared in our associate journal, *Manufacturing Chemist*. The Institute was set up by Sterling Drug Inc., one of America's largest manufacturing chemists, and it consists of a four-storey, three-wing building, occupying 167,000 sq. ft. on a 70-acre site. The staff numbers 200.

Divisions of the Institute are: Analytical laboratory, virus laboratory, pharmacodynamics laboratory, biochemistry development laboratory, physical chemistry laboratory, pharmacy division, chemical development laboratory and a high-pressure laboratory.

The extractors and reactors shown in the photograph on the right are in the biochemistry laboratory, where they are used to isolate natural products of therapeutic importance. Protein hydrolysates were being processed when the photograph was taken. Similar operations include the extraction of the anti-pernicious anaemia factor, vitamin B_{12}, from beef livers.

The pharmacy division, where new drugs are prepared in the form in which they are eventually marketed, is the location of the triple-distillation unit for producing pyrogen-free water, which is shown in the photograph on the left. Other equipment here is a rotary tablet machine in a dehumidified chamber and a special room for the vacuum sealing of ampoules.



The physical chemistry laboratory has an important function, for it is frequently able to provide new approaches to research problems by conducting measurements on a quantitative scale. Equipped with many kinds of precision instruments, it acts as a consultant to the chemical laboratories on such problems as absorption spectra and stability of new compounds which may be useful as drugs. It possesses one of the few recording spectro-photometers in the U.S.A., and physical properties of many materials are investigated; dentrifice powders, for example, are measured for fineness in order to select the most suitable.

In the high-pressure laboratory, located in a detached room below ground level, every precaution has been taken to guard against danger. Built of heavily reinforced concrete, it is separated from the main building by concrete walls and 6 ft. of sand. It houses a wide range of hydrogenating equipment, as well as a number of specially designed autoclaves for reactions requiring high temperature and pressure up to 5,000 lb./sq.in. Operation is by remote control, and the operator is protected by a 12-in. concrete barrier backed by armour plate.

Plant for Fractionation of Cottonseed

RECENTLY a new process for the fractionation of cottonseed meats has been reported on a pilot-plant scale. This process, termed differential settling, removes the whole pigment glands from the meats, producing oil, a pigment gland fraction and a cottonseed meal essentially free of oil, hulls and pigment glands. The commercial application of this process is discussed by R. M. Persell, *et al.* (U.S. Dept. of Agriculture) in the *Jnl. of the Amer. Oil Chemists' Soc.*, 1950, **28** (10), pp. 383-386.

A preliminary cost study was made of a combination screw-press extraction-fractionation plant. For this purpose a model 200-ton/day combination screw-press extraction-fractionation plant was planned. The flow diagram shown was selected as a possible industrial application.

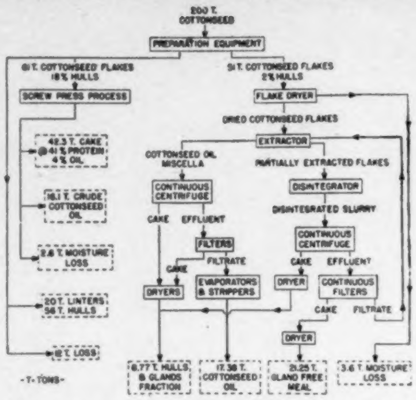
The cottonseed are run through conventional preparation machinery operated so that half of the seed are fed to the extractor as practically hull-free whole meats; the remainder of the meats are processed by continuous screw presses. The extractor is operated so that the defatted meats contain 4 to 6% oil; the remainder of the oil is recovered in the fractionation system. The elimination of the last and most difficult phase of the extraction cycle increases the capacity of the extractor considerably over that obtained when the meats are defatted to less than 1% oil. In the fractionation system the defatted meal is further defatted to less than 1% oil and separated into a pigment gland fraction and a fine meal essentially free of oil, hulls and pigment glands. The products from the combination plant are linters and hulls from the seed preparation equipment; crude oil and meal cake from the continuous screw presses; and crude oil, purified meal, hulls, miscella cake and pigment gland fraction from the extraction-fractionation system.

Equipment

The major items of equipment for such a plant include conventional preparation equipment for 200 tons/day of cottonseed; screw-presses with auxiliary equipment for 61 tons/day of cottonseed meats; a dryer for 51 tons/day of cottonseed flakes; an 80-ton/day solvent-extraction unit with auxiliary equipment; a 50-h.p. dissolver-type disintegrator; a continuous horizontal 32 by 50 in. bowl centrifuge for separating the disintegrated slurry into an effluent containing the finer than 300-mesh meal; two pressure leaf filters for the recovery of the fine meal from 231 tons/day of effluent; and a drier for removing the solvent from 21 tons/day of purified fine meal.

Economics

The estimated original cost of this plant, including the buildings, on a 1948 cost basis was $1,328,120. The cost of con-



Flow diagram of 200-ton/day combination screw press extraction-fractionation plant.

verting the seed, the values of the products and the spread between the value and the cost of the products were also calculated. A comparison of the spreads for the screw-press and extraction-fractionation operations indicates that the cost of fractionation is in line with other types of processing. However, the economic advantage of the combination plant over the screw-press operation as shown was small in comparison with the large additional investment required for the combination plant. The authors opine that the present value of the fractionation process lies in the production of two new products, a purified high-protein meal and a concentrated pigment gland fraction, and in the possibility of producing a high-grade oil, as the removal of the whole pigment gland prevents the material from coming in contact with the oil. The quantity production of the purified meal and the pigment glands is making possible the investigation of the meal and pigment glands for possible industrial and other uses.

Further pilot-plant work under way indicates improvements in the process, such as a high recovery of the meal as purified fine meal. The development of additional and more profitable uses for the products would increase their value and provide a broader and more stable market for cottonseed. Such development would make fractionation, already technologically interesting, a field economically advantageous.

Handbook for the Spectroscopist

THIS book* is intended, according to the foreword, to assist those who wish to analyse ores, minerals, alloys and inorganic chemicals or wish to teach others to do so. There is a general emphasis throughout on the relative ease of provision of rapid approximate analyses of ores and minerals in particular, by examination of their visual spectra.

The author's advocacy of the construction of simple home-made spectroscopes is commendable for this type of work, and generally the book contains some useful practical advice for those concerned with this relatively limited field.

Unfortunately, it suffers from a number of defects, some rather serious.

From the point of view of the newcomer to spectroscopy, for whom the book is clearly intended to provide, the failure to define terms logically and in sequence will be a drawback; thus, there is no clear exposition of the boundaries of the regions of the electromagnetic spectrum of spectroscopic interest; the Angstrom unit is not defined until p. 59, and the basic terms 'spectroscope' and 'spectrograph' are not explained and distinguished until a footnote on p. 46 is reached.

Insufficient attention appears to have been paid to limiting the scope of the manual, and as a result much irrelevant material is included; the notes on infra-red work and on the Quantometer are of doubtful value in a book intended for the type of reader mentioned in the foreword. It is difficult to see the importance to the spectroscopist of information such as 'Samson's fetters and Goliath's helmet were made of brass' (p. 172), or 'potassium iodide is often prescribed for asthma' (p. 127); more than half of the chapter on 'Characteristic Lines of the Elements' is devoted to information of non-spectroscopic character readily obtainable from the standard literature.

On the other hand, there are some surprising omissions from the spectroscopic aspect; there is no lucid statement, for example, of the internal standard technique of Gerlach, which is surely the backbone of the bulk of modern quantitative analytical techniques.

The bibliography is rather unbalanced. The inclusion of Smyth's 'Atomic Energy' valuable as it is in its own field, is inexplicable in the absence of such standard texts as Sawyer's 'Experimental Spectroscopy' or Harrison, Lord and Loofburrow's 'Practical Spectroscopy.'

The number of typographical slips is regrettably high; the erroneous figure for the percentage of silver in silver chloride on p. 76, the confusion in the text over figures 2 and 3 and the misprint 'colodium' for 'columbium' are only a few examples of unsatisfactory proof-reading. This unfortunately tends to undermine confidence in many of the numerical tables.

This manual might have served a most useful purpose with more selective choice of matter, better planning and more careful checking.—F.J.W.

**Manual of Spectroscopy*, by T. Cutting. Chemical Publishing Co., New York, 1949, pp. 220, $6.50.

New Plant and Equipment

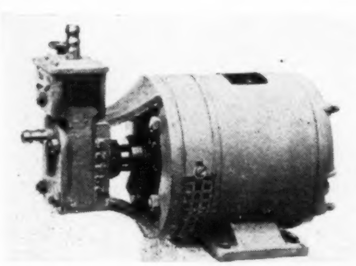
Compact vacuum pump

To meet the demand for a vacuum pump which can be moved around easily in a laboratory, the Pulsometer Engineering Co. Ltd. has developed the 1-in. F.R. compact pump. The weight of the complete unit with motor is only 33 lb., and it is completely free of vibration, permitting it to be run on a bench or table without bolting down.

The close-ground cast-iron cylinder has mounted on it an eccentric rotor of smaller diameter, running in line contact with the top of the ground horizontal bore. The rotor carries two sliding vanes running in a closely toleranced slot which sweep out the air space in the cylinder of the rotor. The top of the cylinder casting is extended to form an oil well which seals the rotary-disc type discharge valve and feeds oil to the cylinder bore for lubrication purposes.

To prevent air leakage to the pump along the driving shaft a special rotary seal is used which, besides being perfectly air-tight under working conditions, reduces the power absorbed and does not score and wear the shaft. This seal consists of a hardened ground and lapped steel cup which is pressed by means of a spring against a prepared rubbing face on the cylinder cover. Interposed between the spring and cup is a square-sectioned rubber ring, backed by a steel follower ring, the rubber ring being a tight fit on the shaft and in the cup. Driven by the fit of the rubber ring on the shaft, the whole assembly rotates with the lapped face of the cup bearing on the stationary front cover. To complete the seal the entire space is filled with oil fed from the main systems. The action of the oil on the rubber ring makes it stick firmly to the shaft and rotary seal cup, and this adhesion is so strong that firm pressure is needed to dismantle the rotary seal from the shaft after it has been in use.

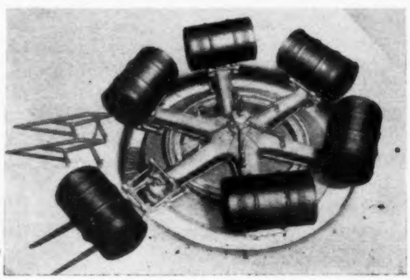
A flexible sleeve-type coupling connects the pump and motor, which gives great simplicity of construction, so that the pump can be stripped, cleaned and reassembled in a matter of minutes without the use of special tools.



Laboratory vacuum pump weighing only 33 lb., and thus easily portable.

Automatic barrel washer

An automatic barrel-washing machine, designed originally for washing casks in breweries, has been shown to have advantages adaptable to the industry's washing requirements. The machine consists of six arms, which project from a central pillar and are supported on an annular table. At the end of each arm is a cradle fitted with supporting rollers, which can be adjusted to take varying sizes of barrels, and a projecting nozzle that fits into the bung hole. The reciprocating and rotary motion imparted to each nozzle gives a fantail spray, which ensures thorough cleaning. Once the barrels are in position, subsequent operations are automatically controlled by the mechanism. Cleaning may be done by steaming, hot water, or both combined; by compressed air, or by any suitable petroleum product. Barrel washings drain from a shallow trench into a sump for removal. Loading and discharge ramps for dirty and clean barrels are so positioned that one attendant only is required to operate the machine.

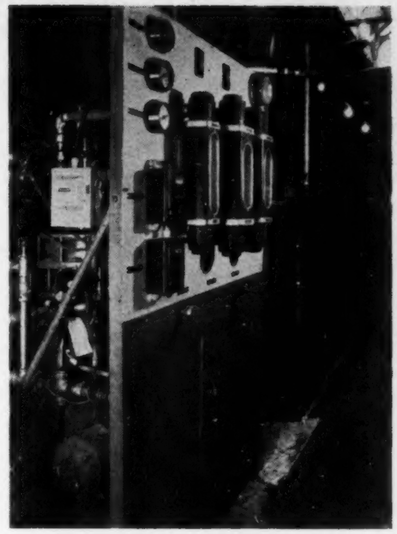


With this automatic barrel washer the washing rate can be varied from 20 to 180 hr. according to type of treatment necessary.

At normal operation speed each barrel is steamed/washed for a period of 2 min. 10 sec., and the rotation period gives a total production of 120/hr., but a gear box can be provided to vary the washing rate between 180 and 20-40/hr., thus enabling barrels requiring different treatment to be handled economically.

The overall diameter of the machine is 11 ft. 6 in., height 3 ft., and standard equipment supplied consists of a central panel for selective washes, motor and pump for water-pressure feed, motor drive and reduction gear. The arms can be removed at will for maintenance and the machine can be operated with any number of arms between three and six. By means of slight modifications, barrels may be mounted vertically on the cradles to suit different positions of bung holes.

Designed by Thos. Ryder & Co. Ltd., the *Roundway* cask-washer is distributed by Allen Oil Equipment & Supply Co. Ltd., London.



Unit for automatic and continuous emulsification of liquid rosin size.

New rosin emulsifier

A commercial unit for the automatic and continuous emulsification of liquid rosin size has been designed for the paper industry. Liquid rosin size is shipped as 70 or 80% solids and, before addition to the stock system, must be diluted to about 4% solids. Emulsification is necessary to disperse the water-insoluble free rosin present in the size so that it will distribute readily in the fibre finish and floc uniformly with alum to give ink, lactic acid and water resistance to the paper. An improperly made emulsion may contribute to wet-press sticking, felt-filling and non-uniform paper sizing.

The general procedure has been to disperse the thick size by severe mechanical action in the 'batch'-type process.

The new emulsifier, which has been in operation for several months, measures about 5 ft. wide, 4 ft. deep and 6 ft. high, and takes up no more space than the ordinary office desk. On the other hand, the older process requires much more space, plus several emulsion storage tanks. The floor space gained through the small dimensions and the elimination of multiple emulsion storage tanks may, in itself, pay for the unit in many paper mills.

Flexible in capacity, the unit can handle up to 12 tank cars of rosin size per month. Dilute emulsion can be supplied as low as 1.5% concentration without need of additional storage facilities.

Close control and accuracy is possible with the new unit. The emulsifier is designed to run smoothly day after day and to deliver uniform emulsion at all times to the paper mill supply system. Accuracy of dilute size is within $\pm$ 0.1% of the desired solids content of the emulsion.

Should some integral part of the system go wrong, safety interlocks have been incorporated in the unit which will prevent it being started or, if running, will shut it

down. The unit is electrically interlocked so that it is automatically stopped and started by means of a float switch located in the dilute storage tank. Thus automatic operation is assured.

Since the unit does not require the time of two or three men daily, as does the batch type, many plants may be able to write off the cost of installation within a year through labour savings alone. Makers of the new emulsifier are American Cyanamid Co.

Multicolumn countercurrent molecular still

A new multicolumn countercurrent molecular still has been designed by S. L. Madorsky and described in the *J. Research Nat. Bureau of Standards*, **44** (2), p. 135.

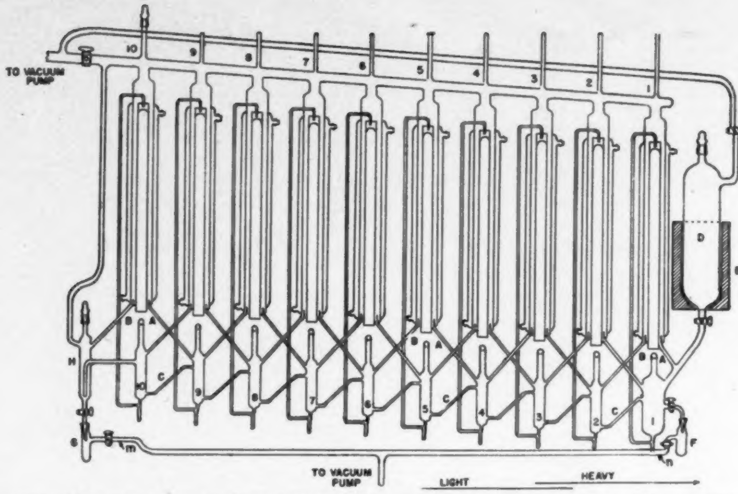
It was devised with the objects of: (1) Obtaining a large evaporating surface so that it could be used commercially for the concentration of individual components in mixtures of liquids different in their molecular weights or vapour pressures, but having similar properties otherwise; (2) spreading the evaporating liquid in a thin film so as to reduce the hold-up; (3) imparting to the thin film a continuous motion over a rough granular surface to cause mixing and thus to prevent depletion in the light constituents; and (4) increasing the efficiency of the distillation process by eliminating mixing of the vapour between cells or plates.

The still consists of 10 columns, but any number of columns can be used. The entire apparatus is constructed of *Pyrex* glass. The columns are arranged from 1 to 10 as shown above in an ascending order from right to left.

In this arrangement the residue from each column, except the first, flows through the outlet *A* into the reservoir of the adjacent lower column to the right. The residue from the first column flows back into its own reservoir. The condensate from each column, except the tenth, flows through the outlet *B* into the reservoir of the adjacent higher column to the left. The condensate from the tenth column flows into a light fraction receiver *H*, and from there into the reservoir of the tenth column. In this manner the residues or heavy fractions flow from column to column in the downward direction from left to right, whereas the condensates or light fractions flow from right to left in an upward direction.

In order to keep the system in balance it is necessary, in the first place, to have the same pumping rate for all columns and, in the second place, to evaporate exactly half of the liquid pumped into the crown of each column. The evaporating rate is more difficult to control. At any rate, it would be practically impossible to control pumping and evaporating rates to a point where there would be an exact balance between the liquid streams moving in opposite directions.

In order to blanket any deviation from



Arrangement of new molecular still. For explanation of numbers, refer to text.

conditions of balance, the evaporating rates in the columns were adjusted to a little over 50% of the amount of liquid pumped into the crown of each column. The fractions of condensates in excess of residues are allowed to flow by gravity from reservoir to reservoir in the direction from the light end (reservoir *H*) to the heavy end (reservoir 1) through overflow tubes *C*. This is made possible by staggering the reservoirs as well as the columns at an angle of a few degrees to the horizontal, sloping from reservoir *H* down to column and reservoir 1. This arrangement serves also the purpose of refluxing the light fractions from reservoir *H* down the series of reservoirs towards the first one.

A large reservoir *D*, surrounded by a *Nichrome* heater *E*, serves to de-gas the liquid before it is introduced into the still. This reservoir is connected to the same vacuum system as the still, but can be isolated from it by means of stopcocks, when filling it with fresh liquid. The system is evacuated by means of an oil pump backed up by a mercury-diffusion pump. Sampling of the liquid can be carried out at the extreme ends of the still into cups *F* and *G* without interrupting the operation of the still.

Electronic radiation pyrometer

A new type of low-temperature radiation pyrometer has been installed in an aluminium hot-rolling mill at Rogerstone, recently opened by the Minister of Supply. This equipment enables the temperature of the aluminium strip to be measured from 150°C. upwards without physical contact with the metal. Three units are installed on the hot-rolling mill to measure the temperature of the billets prior to rolling, at an intermediate stage, and as they leave the mill. The temperatures are indicated on the main control desks and in the central control cabin for the whole line. Previously it was necessary to stop the line and utilise contact pyrometers.

This new radiation pyrometer was developed at the instigation of the Northern Aluminium Co. Ltd., the owners of the mill, by British Electronic Products (1948) Ltd.

Direct-writing polarograph

A direct-writing polarograph, first shown as a prototype model at the Physical Society Exhibition in 1948, is now in commercial production. It performs the same functions as the standard photographic-type polarograph, and consists of a robust direct-writing galvanometer with amplifier, potentiometer and chart driving mechanism.

The instrument has a high stability linear amplifier, of negligible input resistance, which operates a pointer galvanometer carrying the recording pen. Amplification is variable in steps between 0.4 mm./microamp. and 400 mm./microamp. The potentiometer is graduated from +0.4 to −1.4 V at 5 mV intervals and the range can be doubled or halved.

When high-precision measurements are required, adjustment of current through the potentiometer is made against a standard cell contained in the instrument. Damping is effected by a novel system whereby the shape of the curves for average current is virtually unimpaired and allows more certain recording of substances the reduction potentials of which lie close together. The degree of damping is adjustable in six steps and is accurately reproducible.

The plate to which the chart is attached has cylindrical curvature equivalent to the arc of motion of the pen, and this ensures uniformity of current readings, the linear displacement on the chart being proportional to the angular movement of the galvanometer. The applied potential can be read through a window as the record is being made.

The instrument is simple to operate and records are immediately available for analysis. It is made by the Cambridge Instrument Co. Ltd.

Gas-flow speedometer

Measurement of gas-flow velocities has generally involved the use of some scheme that offers impedance to the flow. A limitation of this method is the case where gas is moving at supersonic velocities past or through a fixed object, or a projectile is moving with such velocities through a relatively motionless gas.

A combination of pulse, ionisation and electrometer techniques to the field of dynamics has resulted in some success in the solution of this problem and is described by G. L. Mellen of the U.S. National Research Corporation in *Electronics*, 1950, **23** (2), p. 80. Tests have been confined to subsonic velocities because of the ease with which these may be produced. The principle, however, is not affected by speed relative to that of sound and its extension to all velocities is conceivable.

If some means of ionisation produces a cloud of ions at a predetermined point in the flowing gas and the ion cloud is timed in its transit between the point of formation and a detection station, then the gas velocity is measured directly.

The essentials of this system are that the time involved in producing the ion cloud must be short as compared with the transit time between stations; the gas velocity being measured must be large as compared to the diffusion velocity so that the character of the ion pulse is not lost; the density of the ionisation must be sufficiently high so that the ion signal may be differentiated from all noises generated within the system; the time of collection of ions of the receiving station must be short as compared to the transit time; and the phase shift through the amplifier must be negligible as compared to the transit time.

The magnitude of the collected signal realised across a 10-megohm input resistor in the vidoe amplifier is of the order of 1 mV.

The ion pulse duration is of the order of 100 microsecs.

Ionisation could be achieved by particles from radioactive sources, but these do not lend themselves readily to pulse operation and therefore electron beams are being investigated.

Electrons are chosen over x-rays because of their higher specific absorption in the gas. The electron beam is being produced by a linear accelerator of the resonant cavity type. Energies of the order of 100 kV at a peak current of 10^{-5} A. are desirable for the present application.

New Plant and Equipment

Fill in the Enquiry Coupon on page 88 for further details of the equipment and plant described in INTERNATIONAL CHEMICAL ENGINEERING.

Meetings

Institution of Chemical Engineers

February 17. North-Western Branch. 'A Mechanical Analogue for the Solution of Distillation and other Separation Problems,' by N. L. Franklin, J. S. Forsyth and H. Winning, 2.30 p.m., the University, Leeds.

February 24. Midland Branch. 'The Behaviour of Gas Bubbles in Relation to Mass Transfer,' by C. T. Meiklejohn and P. D. Coppock, 3 p.m., Latin Theatre, the University, Birmingham.

Society of Chemical Industry

February 13. Chemical Engineering Group. 'The Manufacture of Alginates,' by C. W. Bonniksen, 5.30 p.m., Burlington House, London, W.1.

February 15. Road and Building Materials Group. 'Paint and Design,' by Dr. L. A. Jordan, 6 p.m., Institution of Structural Engineers, 11 Upper Belgrave Street, London, S.W.1.

Institute of Petroleum

February 14. 'Petroleum Waxes,' by T. C. G. Thorpe, 5.30 p.m., Manson House, 26 Portland Place, London, W.1.

Institute of Fuel

February 21. East Midland Section. 'Recovery of Ethylene and Propylene from Oil Gases,' by Dr. M. Ruhemann, 7.15 p.m., Electricity Showrooms, Derby. Joint meeting with the British Association of Chemists.

February 21. Midland Section. 'Drying in the Pottery Industry,' by S. Hind, 'Drying of Heavy Clays,' by H. H. Macey, 'Refractory Brick Drying,' by Dr. A. L. Roberts, 7 p.m., Lecture Hall, Midlands Electricity Board, Stoke-on-Trent.

February 21. Yorkshire Section 'Britain's Fuel Policy,' by Sir Claude Gibb, 6.30 p.m., the University, Leeds.

February 26. Midland Students' Section. 'Underground Gasification of Coal,' by R. G. Temple, 7.30 p.m., the University, Edmund Street, Birmingham.

March 6. North-West Section. 'Drying in the Textile, Paper and Allied Industries,' by R. R. Clegg, 'Drying in the Paper Industry,' by A. W. Western, 'Baking Crease-Resisting Finishes,' by J. Sharpe, 'Drying of Dyed Viscose Rayon Cake,' by W. H. Best Gordon, 'Migration of Dyestuffs during Drying,' by R. W. Speke, 'Accelerated Cylinder Drying,' by E. H. Jones, 'Aspects of Circulatory Drying,' by F. W. Thomas, 'Stentering Machines,' by Dr. S. F. Barclay, 'Drying in the Photographic Industry,' by A. K. Soper, 'Wool Drying,' by B. Lincoln, 10.30 a.m. and 2 p.m., Engineers' Club, Manchester. This meeting will be repeated on March 14 at the same time at Bradford.

March 7. Midland Section. 'A Review of Methods of Measuring Burning Velocities,' by Prof. F. H. Garner and Dr. R. Long, preceded by a tour of the Combustion Laboratories of the University Chemical Engineering Department, 3 p.m., the University, Edgbaston, Birmingham, 15.

Chemical Society

February 22. 'Some Aspects of Infra-Red Measurements,' by Dr. H. W. Thompson, 7.30 p.m., North British Station Hotel, Edinburgh. Meeting repeated February 23, 5.15 p.m., Chemistry Department, United College, St. Andrews, and March 8, 6 p.m., University College, Cardiff.

March 1. 'Solid and Catalytic Reactions with reference to the Practical Problems of Industry,' by Prof. W. E. Garner, 7 p.m., Chemistry Department, the University, Bristol.

Institute of Metals

February 8. 'The Metallurgy of Uranium,' by E. W. Colbeck, 7 p.m., 4 Grosvenor Gardens, London, S.W.1.

February 22. 'Metals for Gas Turbines,' by J. M. Robertson, 6.30 p.m., James Watt Memorial Institute, Great Charles Street, Birmingham.

Manchester Metallurgical Society

February 14. 'Instrumentation of Steel-Making Furnaces, Some of the Problems,' by R. Toye, 6.30 p.m., Engineers' Club, Albert Sq., Manchester. Joint meeting with the Iron and Steel Institute.

February 28. 'Clad Steels,' by W. Barr, 6.30 p.m., Engineers' Club, Manchester.

Royal Institute of Chemistry

February 16. 'Corrosion Processes and their Prevention,' by W. H. J. Vernon, 6.30 p.m., Brighton Technical College.

March 2. 'Rockets and their Chemistry,' by J. G. A. Griffiths, films and lecture, 6.45 p.m., Woolwich Polytechnic, London, S.E.18.

March 8. As above, 6.30 p.m., West Ham Municipal College, Romford Road, London, E.15.

Institution of Works Management

March 1. 'Maintenance,' by B. E. Dovey, 7.15 p.m., Royal Hotel, Bristol. Joint meeting with the Incorporated Plant Engineers.

March 6. As above, 7.30 p.m., Grand Hotel, Sheffield.

Oil and Colour Chemists' Association

March 5. 'Heat Transfer,' by D. Ormston, 7 p.m., Royal Station Hotel, Hull.

Hull Chemical and Engineering Society

March 6. 'The Soap Industry,' by J. B. Wilkinson, 7.30 p.m., Church Institute, Hull.

Manchester Association of Engineers

February 16. 'Modern Methods of Painting Machinery and Workshops,' by S. A. Wood, 7 p.m., Engineers' Club, Manchester.

World News

GREAT BRITAIN

New phosphorus factories

Three new factories are now under construction for Albright & Wilson Ltd. (see INTERNATIONAL CHEMICAL ENGINEERING, August 1950, p. 377). One, at Portishead near Bristol, will produce sufficient phosphoric acid for another 50,000 tons p.a. of tripolyphosphate to be made in another new factory at Kirby, near Liverpool. The third at Barry Dock, near Cardiff, will probably manufacture silicones and organic phosphorus compounds. It is hoped that all three factories will be in production by 1953.

Less hydrochloric acid

One of the first effects of sulphuric acid rationing (see p. 59) has been a cut in supplies of hydrochloric acid. Generally, there has been a 20% cut, but in those cases where sulphur-based sulphuric acid is used to produce the hydrochloric, the cut is as much as 35%.

Another underground gasification system

There are now two underground gasification of coal projects in Britain. Details were given last month by Dr. H. R. Cox, chief scientist to the Ministry of Fuel, at a luncheon of the Coal Industry Society in London. The first project had been started on July 13, 1950, and was still working.

It had been engineered by creating a U-shaped channel with two vertical holes in a coal seam. A second project had been working only a few weeks and in this case the method used had been the connecting of two vertical drillings with pneumatic pressure. There was much poor-quality coal in the country not worth mining and a great deal of it could be used by underground gasification. From coal which was half dirt and existing in only an 18-in. seam, gas of an average of about 75 B.Th.U./cu.ft. was obtained. Such a gas could be readily used as the fuel for a gas turbine engine generating electric power.

Dr. Cox described new experiments with a gas turbine with pre-heating apparatus which would burn methane, found in the ventilating air in upcasts from mines. Sir Alfred Egerton, he said, had done experiments which showed that a 1% mixture of methane in air would burn easily if heated to 980°C. Given good fortune, they would see an engine working at a pit about the middle of 1952.

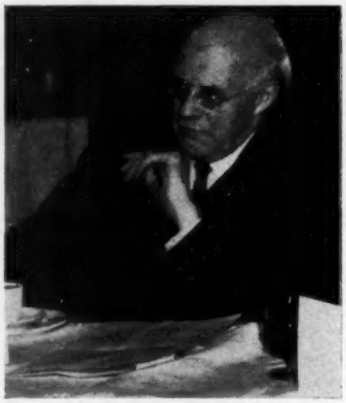
Heat pump for Festival hall

A heat pump utilising Thames water has been built to warm the Royal Festival Hall at the Festival of Britain. In hot weather it will be run in reverse—as a refrigerator—to cool the hall.

Kestner chairman tours S. Africa

Mr. J. Arthur Reavell, chairman of Kestner Evaporator & Engineering Co. Ltd., London, and Kestner (S.A.) (Pty.) Ltd., Johannesburg, recently left England for South Africa. During his stay he is visiting a number of works where Kestner plants and processes are being erected and discussing new projects with leaders of the South African chemical, food and allied industries.

Kestner (S.A.) (Pty.) Ltd. is now manufacturing in the Union more than 90% of their orders; only the specialised parts have to be shipped from England.



SIR HAROLD HARTLEY, F.R.S.

who has been nominated president of the Institution of Chemical Engineers for 1951-52, in succession to Prof. D. M. Newitt. The election of president and other officers will take place at the 29th annual meeting of the Institution to be held at 11 a.m. on Friday, May 18, at the May Fair Hotel, London.

Sir Harold was born in London on September 3, 1878. During the first world war he rose to the rank of brigadier-general and was Controller, Chemical Warfare Department, Ministry of Munitions, from 1918-19. He was chairman of the Fuel Research Board, 1932-47, and vice-president and Director of Research, L.M.S. Railway, 1930-45. He was chairman of the British Overseas Airways Corporation from 1947-49. Since 1935 he has been chairman of the World Power Conference. In his presidential address to the British Association last year he dealt with man's use of energy and we summarised his remarks in our October issue.

New B.S.I. director

The British Standards Institution have appointed Mr. H. A. R. Binney, C.B., to be their new director and secretary in succession to the late Mr. Percy Good, C.B.E.

Big order for mill linings

An order for approximately 1,200 tons of manganese steel castings for lining ball and rod mills at a large copper mine in Chile has been obtained by Edgar Allen & Co. Ltd. As the order originated in New York, some $260,000 are involved in the transaction. A portion of the castings are to be made in the steel foundry of Edgar Allen's subsidiary company in France.

Chemists choose London for Festival year meeting

This year's annual meeting of the Society of Chemical Industry is to be held in London from July 9-13, with headquarters at the Imperial College, South Kensington. This decision was made partly because of the importance of this, the 70th, meeting for which London seemed the appropriate setting, and partly because of the Festival of Britain that is being held this year. Already some 1,300 scientists and their guests, many from the provinces, the Empire and other countries of the world, have said they wish to attend the meeting.

Organisation of the meeting, as is customary, is in the hands of the Society's local section, in this case the London Section, under the chairmanship of Dr. A. C. Monkhouse, Fuel Research Station, with Mr. E. L. Streatfield as hon. secretary. A programme of lectures on the principal theme 'Water in Industry' is being arranged. In addition, many visits to factories and laboratories are being organised.

More aluminium from Canada

Arrangements have now been made by the Ministry of Supply with the Aluminium Co. of Canada Ltd. for the supply to the U.K. in 1951 of 50,000 metric tons of virgin aluminium in addition to the 150,000 metric tons already contracted for and for the supply in 1952 and 1953 of 220,000 metric tons p.a.

The U.K. Government has agreed to fund afresh over a period of 20 years the loans made to the company during the war to finance the expansion of capacity in Canada and to make a new loan to the company of $25,000,000 towards the financing of further expansion. The company will give the U.K. a first call on 200,000 metric tons p.a. of its production for 20 years.

Adequate provision has thus been made for the rising requirements of defence and for essential civilian production. This does not mean, however, that supplies to industry will be unrestricted.

New chemical directory

The 1951 edition of their directory, 'British Chemicals and their Manufacturers,' has been issued by the Association of British Chemical Manufacturers. This edition is more comprehensive than the previous one and contains all the features of previous editions which have, in the light of past experience, proved useful to inquirers. Copies are available, free of charge to persons or firms genuinely interested in the purchase of chemicals. All inquiries for copies should be addressed to the Association at 166 Piccadilly, London, W.1.

Liquid fuels lectures

A course of lectures on 'Liquid Fuels, their Properties and Utilisation' is being given by G. F. J. Murray at the Northampton Polytechnic, London, E.C.1, on Tuesdays at 7 p.m. from February 6 to March 13 inclusive.

Zinc shortage

The production of zinc oxide will be cut during the first quarter of this year, as supplies of ordinary grade zinc for this purpose are to be reduced to 50% of the average monthly rate of consumption for the first nine months of 1950, according to a recent statement by the Minister of Supply. Arrangements are being made by the Board of Trade with the zinc oxide manufacturers to curtail drastically the supply of zinc oxide for paint so as to increase the supplies available for rubber and other essential uses.

A provisional list of prohibited uses of zinc, copper and/or copper alloys has been issued.

Copper, lead and zinc sales

The prices at which copper, lead and zinc will be sold (subject to licence) by the Ministry of Supply to consumers in the U.K. will now be the prices ruling on the next working day after the consumer's order is posted, and not, as at present, the day on which the order is posted. This ruling took effect on January 8.

Festival factory visits

British manufacturers who are willing to receive visitors at their factories during the Festival of Britain, 1951, are invited to send particulars to the Council of Industrial Design. The Council will compile a list of such firms and arrange for it to be carried at all industrial information bureaux in the official Festival exhibitions. The list will be issued to visitors on presenting a trade or business card. Letters should be sent to Mr. S. D. Cooke, Council of Industrial Design, Tilbury House, Petty France, S.W.1, and should include the name and address of the factory, some particulars of the goods made, the approximate number of employees in the factory or other indication of size, the most convenient days and hours for receiving visitors and the person to whom visitors should apply in advance.

Naphthenic acid dearer

As a result of increased costs, Shell Chemicals Ltd. have had to advance their prices of naphthenic acids. The new prices, which took effect on January 1, are:

	Grades			
	*N.A.*9	*N.A.*20		*N.A.*17
	£	£	s.	£
40-gal. drums	112	97	10	83
1—5 tons ..	111	96	10	82
5—10 tons ..	110	95	10	81
10 tons and up	109	94	10	80

AUSTRIA

Fertiliser production

The Austrian Nitrogen Works (Oesterreichische Stickstoffwerke) of Linz, turned out 365,000 tons of their chief product, 'Kalkammonsalpeter'—a mixture of lime and ammonium nitrate—in 1950. This figure is 35% above the 1949 level of 296,000 tons. Over a million tons have been produced since the end of the war. The concern now covers the whole of the requirements of Austrian agriculture, and at the same time it is one of the chief earners of foreign exchange among the nationalised undertakings. Total exports by the concern in 1950 amounted to 298,000 tons valued at about $11,000,000.

BELGIUM

Porphyry output up

Belgian output of crushed porphyry in 1950 totalled 2,700,000 tons—a third more than was produced in 1949, but still some 300,000 tons below the average pre-war level. The increase over the level of the preceding year was achieved largely as a result of new methods and greater mechanisation, and in spite of a labour shortage. The stock of 400,000 tons of porphyry on hand at the beginning of the year has been completely disposed of. Holland remains the most important export customer; sales to France have been resumed, but in negligible quantities.

Porphyry is a form of felspathic base or of feldspar.

FRANCE

Petroleum chemical industry develops

The production of petroleum chemicals is increasing in France. Societe Naphthachimie's plant for the manufacture of 60,000 metric tons of naphtha annually, as well as 10,000 tons of acetone and 17,000 tons of solvents and other chemicals, is nearing completion. The plant is expected to be in full operation by 1952.

Another company is installing equipment to produce 10,000 to 12,000 tons of acetone a year from propylene, which is extracted from gas from its oil refineries. A third firm also has added facilities for the production of acetone.

The establishment of a carbon-black plant is under consideration.

GREECE

Plans for chemical plants

A plant for the production of 35,000 tons p.a. of nitric acid, using lignite as the raw material, is projected by the Greek Ministry of Economic Co-ordination, which has asked industrialists to submit plans. The plant is to be built at Ptolemaidu and is to produce also ammonia and nitrogen fertilisers.

Another chemical project being sponsored by the Government is a plant for the annual production of 25,000 tons of caustic soda and sodium carbonate. It is to work in conjunction with a plant producing 150,000 tons p.a. of salt.

An 80,000 tons p.a. aluminium plant using Greek bauxite and a 120,000 tons p.a. steel plant are other projects scheduled for the current financial year. Marshall Aid funds will be used to help finance the programme.

ITALY

Coal-tar products

Although Italy has about 100 coal-distillation plants, only a small number recover coal-tar crudes. Light oils, benzene, toluene and xylene, as well as crude naphthalene and solvent naphtha are principally produced by five groups of plants, in Genoa, Turin, Milan and Rome; two of them are controlled by Montecatini. The manufacture of coal-tar intermediates has assumed additional importance with the development of the plastics industry.

Post-war output of benzene is higher than in 1938. Production of toluene has, however, decreased, but the demand has slackened because of reduced dye exports. Output of xylene is slightly lower than pre-war, and crude naphthalene production is also down, although solvent naphtha output has increased.

SWITZERLAND

Chemical trade controlled

Exports and imports of many raw materials, including a long list of chemicals, are now under strict control as the result of the recent action of the Swiss Federal Council. Exports of scrap iron, zinc, tin, aluminium, glycerine and bones are to be restricted and a close check is to be maintained on all stocks in the country.

Pharmaceutical exports rising

Swiss exports of chemical-pharmaceutical products, which had been rising steadily since 1944, reached a record level last year and exceeded for the first time the value of aniline exports which had also been increasing steadily but to a more limited extent. Exports of chemical-pharmaceutical products during the first 11 months of 1950, valued at 200,056,000 francs, were about 25,000,000 francs above the comparative 1949 level and were well above the 41,900,000 worth exported in the whole of 1938. Exports of aniline dyes rose to 195,329,000 francs from 186,962,000 in the corresponding period of 1949, and compared with exports worth 81,300,000 francs in the whole of 1938.

Trade circles are of the opinion that the favourable trend in exports of pharmaceuticals will continue for some time. However, long-term prospects are viewed with some misgivings as more and more countries concentrate on the import of pharmaceutical raw materials only and are taking measures to hamper imports of speciality products.

At present about half of the Swiss chemical-pharmaceutical exports are go ng to countries belonging to the European Payments' Union. Sales to the formerly important customers in Eastern Europe are declining, while exports to American countries are rising.

NORWAY

Plant modernisation

It is planned to modernise the plant of Det Norske Nitrit A/S at Tyssedal by the installation of 150 furnaces of 45,000 amps, new reduction furnaces, a new foundry with electric smelting furnace, an electrode manufacturing plant, fresh transport equipment for raw materials, and the mechanisation of the internal transport system.

Rising aluminium production

Norway's production of aluminium in 1950 is estimated at between 43,000 and 45,000 tons, compared with about 35,000 tons in 1949. Total world production of aluminium in 1950, excluding the Soviet Union, is put at about 1,300,000 tons. In a survey published by Norsk Aluminium Co., it is stated that the market for aluminium is now very firm, as production is too small to meet the greatly increased demand for civil, military, and stock-piling purposes. In Norway there is an increasing use of aluminium for electric cables. About 1,700 tons of such cables were delivered in 1950. More aluminium is also being used by the Norwegian canning and shipbuilding industries. In the first ten months of 1950, 35,000 tons of aluminium were exported, earning almost £4,000,000.

Chloride of lime to be made

Norsk Hydro A/S is planning to produce chloride of lime, previously imported by the Norwegian Roads Directorate for dust-laying on roads. About 20,000 tons of chloride of lime are required annually and Norsk Hydro estimate that they can produce about 30,000 tons as a by-product in their manufacture of sodium carbonate; surplus production may be exported.

EGYPT

Suez fertiliser plant

At a recent meeting of the Egyptian Fertiliser & Chemical Industries Co. the shareholders were asked to approve an increase of £E1,600,000 in the company's capital, bringing it to £E5,600,000. The money is needed for building a pumping plant at Suez and installing a packing factory.

The managing director, Ahmed Abbud Pasha, stated that production would commence in April next. He told the meeting that the company would be able to purchase butane from Ras Gharib at £E1 per ton instead of £E6 or £E7.

SOUTH AFRICA

New type of sulphide ore furnace

A new type of furnace for roasting complex sulphide ores has been demonstrated in Pretoria before Government mining experts from South Africa and Rhodesia. Developed by a Pretoria man, Mr. C. J. C. Pearton, the process has been patented in the Union and Rhodesia, and further patents have been applied for in Britain, America, Australia and other countries.

Complete and automatic control of temperature is claimed to be achieved, and the formation of other compounds of sulphide is avoided.

The new method of roasting will first be applied to gold mines, but later it may be used for treating base metals and securing industrial oxides. It may lead to the opening up of several abandoned gold mines in the Eastern Transvaal and the establishment of new mines in Swaziland, and the Eastern and Northern Transvaal.

SOUTHERN RHODESIA

Platinum may provide new industry

Southern Rhodesia will become an important world producer of platinum if a new method of extraction can be successfully applied, says the *Rhodesian Herald*. The colony has long been known to possess vast deposits of platinum, but the difficulty has always been the question of extraction. Now, through the efforts of a syndicate of Bulawayo businessmen, a leading British firm of consultants has found a way of extracting platinum from several tons of ore which have been sent from the colony. The next stage will be the erection of a pilot plant to prove that the platinum can be mined on a commercial basis; if this is possible, a large-scale mining venture will be launched.

An exclusive prospecting order covering 70 sq. miles in the Belingwe district has just been granted by the Government in favour of the syndicate. The order stipulates that £25,000 must be spent in operations in the next three years. Mr. J. E. Marzorati, a member of the syndicate, said that the Rhodesia Great Dyke Development Exploration Co. Ltd. had agreed to finance the systematic sampling of the ore. If the sampling has favourable results the company will erect a pilot plant. So far, said Mr. Marzorati, the presence of at least 80,000,000 tons of ore, containing nickel and copper as well as platinum, has been established. Nickel and copper will be obtained as by-products.

INDIA

Chemical engineers meet

The third annual general meeting and technical papers' session of the Indian Institute of Chemical Engineers was held at the Institute at Bangalore on December 30 and 31.

The papers read were: 'Studies in liquid vapour phase equilibrium relations in binary systems,' 'Effect of reflux ratio on packed column distillation,' 'Liquid-liquid extraction by centrifugal action,' 'A note on Edgeworth Johnstone's nomographic chart for fractionating column calculations,' 'Synthetic liquid fuels,' 'Destructive distillation of some hardwood species of the State of Bombay,' 'Pyrolysis of wood,' 'An appliance for tackling leaky gas cylinders,' 'Study of steam consumption under different working conditions in an oil deodorisation process,' 'Dyes for the acceleration of solar evaporation,' and 'Comparative study of the methods for calculating isothermal changes of enthalpy of real gases at high pressures.'

Hydraulic research congress

Two hundred and fifty hydraulic engineers from 27 countries gathered in Bombay last month for a four-day meeting of the International Association for Hydraulic Research. The conference, meeting for the first time outside Europe, was presided over by Dr. Lorenz G. Straup, a leading U.S. authority on hydraulics. Progress in the field of fluid mechanics, design of lined canals, barrages, control of water and sedimentation were among the subjects discussed.

MALAYA

Cement company formed

A cement manufacturing company has been formed. Known as Malayan Cement Ltd., it is expected to start a factory at Rawang in Selangor. Capital is $10,000,000 (Straits). The company is sponsored by Malayan Collieries Ltd. and the Associated Portland Cement Manufacturers.

AUSTRALIA

Ammonium sulphate crystals made for first time

The Australian Iron & Steel Co. has installed at Port Kembla, New South Wales, a plant to manufacture crystalline ammonium sulphate, believed to be the first of its kind in the Southern Hemisphere. The product is used by the Queensland sugar industry and in the manufacture of mixed fertilisers. Ammonium-sulphate fertiliser is being obtained as a by-product from the coke ovens.

NEW ZEALAND

Sulphur shortage cuts fertiliser output

The acting Prime Minister of New Zealand, Mr. Keith Holyoake, announced last month that New Zealand agriculture was faced with an immediate crisis owing to the world-wide shortage of sulphur, essential for the manufacture of superphosphate fertiliser. Rationing of superphosphate—the basic fertiliser in New Zealand's agricultural economy—and the bulking-up of available superphosphate by ground phosphate rock or lime were alternatives to be considered immediately. A long-term plan to produce sulphur from pyrites was also under consideration. New Zealand had planned a production of 750,000 tons of superphosphate this year and needed 90,000 tons of sulphur to make the necessary sulphuric acid. The allocation for the first quarter was to be 13,125 tons—to fit in with the maximum programme of 52,500 tons of sulphur or 451,000 tons of superphosphate.

CANADA

New resin plant

A new plant for the manufacture of resins for the paint industry is due to come into production this month at Weston, Ontario. The plant is owned by Reichhold Chemicals (Canada) Ltd. Mr. D. G. McNabb, technical director of the company, informs us that the plant is located on a 3-acre site adjacent to the Canadian Pacific Railway's Toronto-to-North Bay line, approximately 6 miles north of Lake Ontario. At present there are four buildings, one of which is used for manufacturing and office space, a second for warehousing, and two other buildings, a boiler house and a pump house. There are two tank farms, one for the storage of solvents, the other for the storage of vegetable oils and alkyd resin solutions. When all the manufacturing equipment has been installed, a complete range of alkyd resin solutions, including non-drying alkyd resins for use in the manufacture of lacquers and also in baking enamels, will be manufactured, along with amino-aldehyde resins; drying oil modified alkyds of various oil lengths suitable for the manufacture of industrial and architectural enamels, both baking and air-drying types; and also rosin and drying oil modified alkyds suitable for the manufacture of fast-drying industrial enamels. It is also planned to make drying oil modified alkyd resins containing phenol formaldehyde resin which are used for such purposes as blending with pure drying oil modified alkyds to make automotive refinishing enamels and fast-drying agricultural implement enamels. Certain modified phenolic resins, pentaerythritol and glycerine esters of rosin, and maleic resins suitable for use in the manufacture of oleo-resinous varnishes will also be produced.

By the middle of 1951 the firm expects to have a second Canadian plant in operation near Vancouver, British Columbia. This plant will manufacture urea-formaldehyde and phenol-formaldehyde resins for the plywood and pulp and paper industries in the British Columbia area.

Nickel dearer

In the second quarter of 1950 major increases in costs for refined nickel required International Nickel to raise its U.S. base price of electrolytic nickel to 48 cents per lb., including the U.S. import duty, Dr. John F. Thompson, president of the International Nickel Co. of Canada Ltd., stated recently. Prices in other markets were adjusted correspondingly. The increase brought the price of nickel to a level about 40% above the average price prevailing for all markets in the pre-war years. In the U.K. the Mond Nickel Co. Ltd. has raised its price to £406 per ton, delivered works.

Despite the fact that nickel has been in short supply recently, Dr. Thompson stated, the amount available for distribution and Government stockpiling in 1950 was the largest for any peace-time year in the history of the Canadian nickel industry.

Nickel output by the Canadian producers, International Nickel and Falconbridge Nickel Mines Ltd., for the year 1950 was expected to be approximately 250,000,000 lb. Currently International Nickel's production was running at substantially the average level of the war years.

Chemical plant expansion

A chemical plant for the manufacture of chlorine, caustic soda and sodium sulphide for use in making bleached sulphate pulp is to be established near the Ontario plant of Marathon Paper Mills of Canada Ltd. The new plant is part of a $3,000,000 expansion programme planned by the company. Production of bleached pulp last year from the mill was 103,000 tons, and output is expected to be stepped up this year to 107,000 tons. Marathon Paper Mills of Canada Ltd. is a subsidiary of Marathon Corporation, Menasha and Rothschild, Wisconsin, manufacturers of protective food packaging materials.

U.S.A.

Chemical controls

Should all-out chemical controls become essential to defence production, Government and industry officials in Washington generally favour a broad flexible control order like the M-300 order of the second world war. The *Journal of Commerce* reports that for the most part there is agreement between industry and the Government that a controlled materials plan limiting the end-uses of chemicals would be unworkable because most chemicals are too far removed from end products. The World War 2 order required forms to be filed with a Commodity Administrator before authorisation for use or delivery of controlled chemicals could be made. Small orders for any kind of chemical were exempt from the order.

Minerals must not be hoarded

The Interior Department's Defence Minerals Administration has listed more than 50 minerals as 'scarce and not to be hoarded.' Excessive accumulation of any of these materials now becomes unlawful. The new list supplements a list of finished and semi-finished metals and minerals issued by the National Production Authority on December 27 for the same purpose.

American Cyanamid's president dies

Mr. William Brown Bell, president of the American Cyanamid Co., died of a heart attack in December at Marrakeech, French Morocco. He was on a business trip. His connection with the chemical industry began during the first world war when he became assistant to the president of Air Nitrates Corporation in building the nitrate plant in Alabama. In 1922 he became president of the American Cyanamid Co.

German low-temperature plants to be made

The chemical plants division of the Blaw-Knox Co. has completed arrangements with the Linde Eismaschinen Co., Germany, authorising it to design and construct complete plants employing low-temperature processes. Among the industrial processes made available by this arrangement is one for the tonnage production of oxygen. Tonnage oxygen is, among other uses, of growing importance to steel-making and chemical processing. Among other processes made available by this arrangement are the low-temperature separation of industrial gas mixtures such as coke oven gas, and the separation of rare gases such as argon from the air.

Benzole for rubber

Owing to the diversion of benzole supplies to the programme of increased production of synthetic rubber, output of synthetic detergents based upon benzole is likely to be curtailed. Since this includes about 90% of American synthetic detergent production, the shortages will have a widespread effect.

Trade circles estimate that between 10,000,000 to 12,000,000 gal. of benzole would be made available for synthetic rubber production if there was any material cut-back in synthetic detergent production. In addition, more sulphuric acid would be made available and a reduction of synthetic detergent production would, at the same time, lead to an increased production of soap and eventually to an increased production of glycerine, which is a by-product of the soap industry. The phosphate supply position would also be eased.

New type of cracking unit

Providing a 50% increase in the refinery's capacity for high-quality automotive and aviation petrol, a new air-lift *Thermofor* catalytic-cracking T.C.C. unit was scheduled to go into operation last month at the plant of the Socony-Vacuum Oil Co. Inc., Trenton, Michigan. It is claimed to be one of the first units of its kind in the U.S. to use an air-lift for transfer of regenerated catalyst beads from a kiln to the top of a reactor where the beads are contacted with charge stock to 'crack' it into petroleum components. Ten more such units are scheduled for other Socony-Vacuum refineries.

This 15,000 barrels*/day unit replaces a 10,000 barrels/day Houdry fixed-bed unit. It differs from the Houdry unit in that it uses a constantly-moving bed of catalyst for continuous production of petroleum instead of fixed-catalyst beds which must be closed down periodically for removal of the carbon absorbed by the catalyst.

*42 gal.

Examiners' Comments on Inst. Chem. Engineers Associate Membership Examination, 1950

THE report of the board of examiners on the Associate Membership examination, 1950, of the Institution of Chemical Engineers states that it was the 25th of the series and that there was an entry of 118 candidates. Of these, 77 (65%) satisfied the examiners. The number of successful candidates shows a marked increase over that for 1949, when out of 115 candidates, 61 (53%) passed.

The Home Paper

In each of these two sections candidates must answer one question out of four.

Section A. This year saw the introduction of a recommendation to candidates that answers should not, as a rule, exceed 20,000 words. In consequence, verbiage and extensive quotation from the literature were reduced and detailed treatment of minor features was avoided. Candidates appear to have made a commendable search of the literature; they chose the process with care and applied themselves painstakingly to the design. The chief weakness was a lack of practical experience; this showed itself in over-elaborate design or in the design of units difficult to fabricate. Calculations were sometimes taken beyond the necessary significant figures. The drawings were, on the whole, poor. In general, the answers to this paper were well presented, although some candidates considered (wrongly) that an index to sections of the answer dispensed with the need for a descriptive summary.

Section B. This year's paper consisted entirely of questions of the essay type. Many of the answers submitted suffered from immaturity of style. A further fault was too much quotation from published work, in some cases without acknowledgment.

'Written' Papers

Sections C, D and E each consist of two parts of five questions and candidates are required to answer two from each part. Paper F consists of an exercise in engineering drawing.

Section C. This section is devoted largely to the fundamental principles of heat transmission and fluid flow. Part I consisted of questions each of which involved a calculation. It was noticeable that question 1 on metering a fluctuating oil flow, question 2 on steam expansion in a turbogenerator, and question 3 on the yield from a catalytic process, were not popular, since over 80% of the candidates chose questions 4 and 5. Question 4 on the design of a gas heater was answered fairly well, the principal faults being a misunderstanding of the term 'mass velocity' and arithmetical errors in placing the decimal point. Answers to question 5 on the surface temperature of a lagged steam pipe were also generally satisfactory, but for the unnecessary use of the logarithmic mean for small variations in the temperature difference.

In part II, question 6, on the accurate control of flow for a given purpose, and question 10 on centrifugal pumps, were generally ignored. The calculations in question 7 on the design of a condenser were well done, but the sketches of the equipment showed a lack of practical sense. Question 8, dealing with the conveyance of materials, was well answered and, in question 9, the theoretical treatment and descriptive matter regarding separation of solids by sedimentation were generally good, but few candidates gave the correct solution to the calculation.

Section D. This section deals largely with chemical engineering processes and the questions were very unevenly answered. The calculations in questions 1 on water cooling towers and 2 on pressure drop through a contact mass were badly done, and there were many arithmetical errors, again including the misplacement of the decimal point. Question 3 revealed a lack of knowledge of the method of plotting a curve for rate of drying, and in question 4 a similar lack of knowledge was shown of relationships used in filter press calculations. Question 5 on leaching was generally avoided.

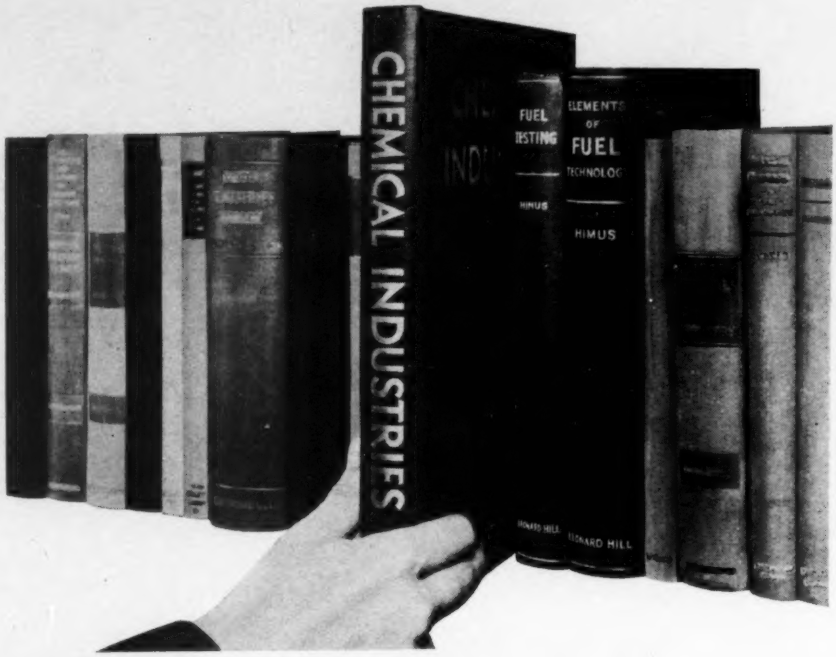
In part II, question 6, on molecular distillation, and question 8 on electrostatic precipitation were popular and generally well answered. Question 7 on the operation of packed columns, was attempted by two candidates only; in each case the answer was unsatisfactory. The answers to question 9 on crystallisation were very poor and showed ignorance of Mier's theory and the supersolubility curve, while in question 10 very few candidates appeared to know how to reduce a mixture of sizes to an average size.

Section E. This section deals with materials of construction, steam and power generation and utilisation, and factory layout and construction generally.

In part I the compulsory question, No. 1, on materials of construction for specific operations, was well answered. Question 2, a calculation for a surface condenser, was popular and the answers were satisfactory. Very few candidates attempted questions 3 on the Mollier diagram, and 4 on heat cycles, indicating a general reluctance to tackle problems in thermodynamics. The satisfactory answers to question 5 on producer gas combustion were marred in some instances by ignorance of the fact that fuel gas analyses are given on a dry basis.

In part II a second compulsory question, No. 6, was introduced for the first time. This was a test of knowledge of fundamental mathematical principles and their application. The answers were poor; it can only be concluded that many candidates do not understand these fundamental principles and take 'standard' equations for granted. The large number of incorrect attempts at part (d) of this question, dealing with fluid flow, was particularly disappointing. Question 7 on corrosion, and question 8 on the working pressure of a cylindrical vessel were not popular, since most candidates chose either question 9 on an a.c. motor or question 10 on boilers; in each case the question was answered correctly, but wordily and almost illegibly.

Paper F. The drawings were generally of a low standard, which has been the case in many previous years. Some 5% of the answers were valueless, showing a complete lack of experience in either reading or making a drawing. It should be emphasised that the first stage in design for the chemical engineer, namely the calculation of heat quantities, pressure drops, and so on, must be followed by translation into engineering practice. These two stages cannot be entirely separated and this translation is facilitated when the chemical engineer is able to make neat and workmanlike drawings.



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